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Modern Zinc Base Die Casting

W. M. PEIRCE

The Structure of Heat-Treated Low Carbon Steel

W. J. CROOK and H. S. TAYLOR

Corrosion and Heat-Resisting Steels As Applied to Automobile and Bus Use

C. M. JOHNSON

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JUNE 1930

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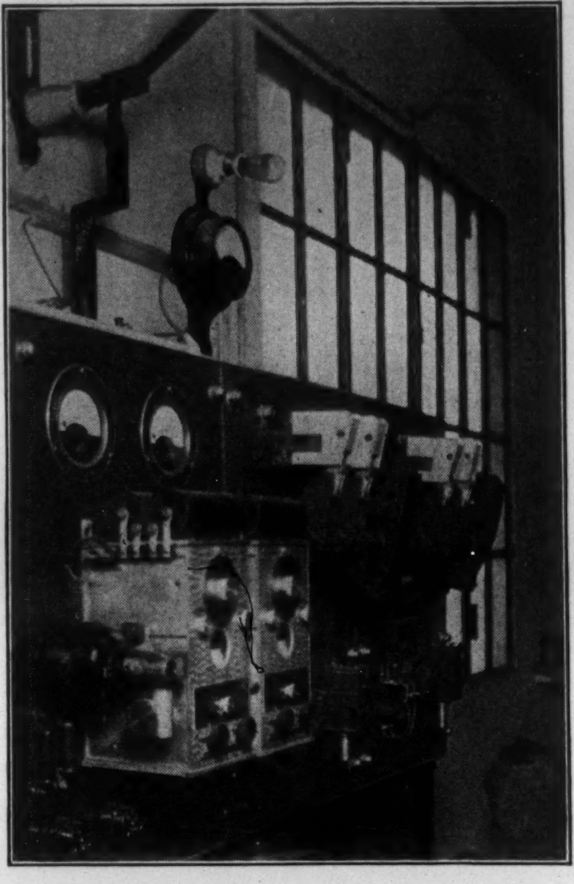

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The* CHEMICAL CATALOG COMPANY, *Inc.

419 Fourth Avenue **New York, N. Y.**

PUBLISHER'S PAGE

Note— On this page the publishers will talk right straight to you each month. We will tell you how things are progressing with METALS & ALLOYS. *We will undoubtedly ask your advice on many points. We are publishing this paper not primarily to please ourselves but rather to serve you. And our office door is always open. You are invited to call.*

The End of the First Year

WITH this June issue we bring to a close the first year of METALS & ALLOYS. Throughout the year, we have had, while attending conventions and going about the country in the ordinary course of business, an opportunity to talk with many of our subscribers. We have been encouraged by the complimentary things that they have said about our paper, and greatly helped by the many useful suggestions and constructive criticism they have offered.

Having found those subscribers we have met personally to be keenly interested in the success of the publication, we have thought it appropriate to give on this page this month to those of our friends we have not had the pleasure of meeting a sort of report of progress, and an outline of what we hope to accomplish during the coming year.

At present we have more than 3100 paid subscribers. Judging from the rate at which subscription renewals are coming in, most of those who subscribed for the paper at the outset have been favorably impressed with it and can be counted on to continue their subscriptions. This circulation has been built up entirely by mail, and by the cooperation of our present subscribers. Our subscription list is growing steadily and we hope to have at least 5000 subscribers by the end of another year. We were particularly gratified by the large number of foundry superintendents and others in that great industry, who visited our booth at the recent Foundrymen's Show in Cleveland, Ohio, and after examining the publication decided to subscribe for it.

With regard to advertising, we have been seriously hampered in our efforts to build up a satisfactory volume of advertising by the general business conditions prevailing since the financial disturbance of last November. The crash came just at the time when most of the large corporations were planning their advertising schedule for this year; and many advertising managers who otherwise would have been inclined to take space in METALS & ALLOYS received instructions not to consider any new publication, no matter how meritorious it might be.

Owing to the fact that each issue of our paper at the present time is being published at a loss, we are exerting every effort to develop increased advertising patronage for 1931; and if we are able to do so, we will be able to enlarge the size of the paper, to provide for the increasingly large number of valuable contributions that are being sent to us, and will also be able to go ahead with various plans we have in mind for the broadening and improvement of the publication.

We hope that you have liked METALS & ALLOYS during its first year. If so, please send in your subscription renewal promptly if you have not yet done so. Also we would appreciate it greatly if you will bring the paper to the attention of any of your friends who might be interested in subscribing and we will be glad to send sample copies to anyone whom you might suggest in the United States or abroad.

Finally, we want to take this opportunity of thanking all our contributors, subscribers and advertisers for the support and encouragement that they have given us during our initial year.

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Editorial Comment

In this department I try to comment on metallurgical and allied matters that seem to me interesting and significant. The views expressed reflect my own personal attitude. Many of our readers will have ideas of their own on these subjects and are urged to contribute them in the form of letters which will gladly be published in succeeding issues.—H. W. GILLETT, *Editorial Director.*

Metallurgy and One of Its Allies

On account of its bearing on increased use of metals and alloys for shot, for shell case heads and for gun barrels and parts, metallurgists may be interested in the work of the Du Pont Company in Game Research. Some metallurgists are hunters too, and will be interested for other than professional reasons.

This is an activity of the smokeless powder division, and is doubtless partly motivated by the desire to increase the use of powder. More game, more hunting, more shots fired, more Du Pont profits, incidentally, also, more sport and more health to the hunter. Nobody will tramp the fields, or sit in a blind as often, or with as much enthusiasm when game is scarce as he will when he has a reasonable expectation of getting a few shots.

Unless he does get a chance to shoot, he brings his shells home again when he does go out, so the connection between game stocking and use of powder is quite clear.

However, a less sordid impulse might also be involved. If increase in the use of powder were the only object, expenditures in popularizing trap shooting and Skeet would obviously bring more prompt returns, for the average hunter fires fewer shells at game in a whole season than the average trap shooter fires in an afternoon. One motive in the expenditure of Du Pont funds for the furtherance of better hunting must be the creation of good will toward the firm. All agencies working for an increase in our game supply deserve good will, and certainly have ours.

It is not primarily the task of the Game Research Division actually to propagate much game for distribution and stocking. Unless each bird raised is missed many times before it is finally dropped, the profits on the powder would not go far toward paying the cost of propagation. Instead, the task is to find out satisfactory methods of game breeding, proper design and use of nesting boxes, field coops, breeding pens, etc., and to pass on this information to those individuals or sportsmen's associations who will use the information. Hence, the hatching in 1930 of several thousand eggs of bob whites and an equal number of ring necks, to say nothing of ducks and geese, is merely the by-product of the search for better breeding methods. Information is disseminated by issuance of a bi-weekly sheet, "Game Conservation News."

In the olden days, our squirrel-hunting ancestors are reported to have refrained from shooting a squirrel till they got him against a tree, so the bullet could be dug out, chewed into shape, and re-used. When the hunter lost his bullet, he had to come home. While there is some reclamation of shot from trap shooting grounds, and some shooters reload their shells, in general, any increase in the number of shots fired makes for a wider market for lead and for cartridge brass. We'd like to see conditions improve so that we and all other hunters might fire so many shots a season at game, that this use of metals would really cut a figure in the metal market.

The really interesting thing about the project is the way research methods are being applied to build up future business and future good will. We hear much about "fundamental" research. If that be defined as the antithesis of research to produce immediate dividends that are obviously due to research, this Game Research work is fundamental.

As is stated at the head of this column, the column is supposed to comment on metallurgical and allied subjects that are interesting and significant. Obviously, this is allied to metallurgy; we rise to state that anything having to do with hunting is a whole lot more interesting than most metallurgy; and the entrance of a firm like Du Pont into a research field of this sort appears to us both significant and encouraging.

The Cheapest 99.9% Metal

If you wanted a cubic foot of a metal, and any metal would do, which metal would be cheapest? You'd be surprised! Here are some approximate figures.

		Cost		
1 cu. ft.	Weight, lbs.	¢/lb.	or	$/cu. ft.
Sodium	61	19½		11½
Ingot iron	480	2½		11½
Zinc	437	5*		22
Lead	708	5½		39
Aluminum	163	24.30*		39½
Antimony	419	7¼*		31½
Copper	557	13		72½
Nickel	550	35*		192½
Tin	460	31¼		143¾

* These prices, as of June 2, 1930, are for commercial grades, less nearly pure than sodium.

We were surprised to learn that metallic sodium is being sold in carload lots, for chemical uses, at 18¢ per lb. Moreover, if the uses of sodium could be increased so as to warrant greater production, it might sell at a price only around a third higher volume for volume, than pig iron.

Even at the present price, it is interesting to let one's imagination run riot in regard to sodium. It is slightly lighter than water, and melts a trifle below the boiling point of water. Its electrical conductivity is such that it only takes about three times the cross section to carry a given current on a sodium wire than it does on a copper wire, but its specific gravity is about $^1/_9$ that of copper. That is, approximately $^1/_3$ the weight of a sodium conductor would do the work of a copper conductor, and would cost, at prices for sodium that would be in sight if sodium conductors came into use, only a fraction as much.

If we filled a thin copper or austenitic (18 Cr 8 Ni) stainless steel tube, strong enough to carry the load, with sodium, and could make provision to avoid difficulties from the high coefficient of expansion of sodium, from the likelihood that it would creep down into the sag of the cable if we left space inside the tube for expansion, and from the danger that would ensue if such a conductor did break, and could work out the problem of making joints and connections, we should have a cheaper conductor than solid copper or aluminum. Crazier things have been done.

At the moment, the outstanding metallurgical uses of sodium are as a modifier in aluminum silicon alloys, and as a hardener for lead. It has interesting possibilities as a deoxidizer. Such small amounts are required in these actual or potential uses that its price would make little difference in its use.

Commercial sodium runs, exclusive of any external corrosion product, and considering the body of the metal, something over 99.9% pure, the principal impurity being calcium, up to around 0.05%.

It certainly is a challenge to the metallurgist when the chemist provides him with so pure and so cheap a metal, one indeed cheaper on a volume basis, than any metal of equal purity he has available to-day. H. W. G.

Readers' Views and Comments

To the EDITOR of METALS & ALLOYS:

Dear Sir: It may interest you to hear something from Holland. Although, our country is the birthplace of that part of physical chemistry which might be called "the phase-rule chemistry," to the evolution of which Bakhuis, Roozeboom, van der Waals, van't Hoff and others devoted their life's work and which forms the base for the progress of scientific metallurgy and metallography, the science of *metallurgy* itself has had but little cultivation here due to the fact that there are no great steel and other metal works in this country. On the other hand, in the great shipbuilding yards, structural building and motor companies, radio and lamp works, artillery works, etc., where the use of the newest inventions of metals and on metal working is applied, *metallography* is more and more studied, and there are nowadays many firms who have erected metallographic and mechanical laboratories for scientific and technical research, with up-to-date equipment, including high power microscopes, Saladin apparatus, modern machines for tensile, bending, impact, endurance tests, etc. In this connection it is interesting to note that my firm has bought a testing machine for determining the endurance limit of electric welds, a kind of repeated flexure machine, specially built for this purpose by a German firm.

Let me correct METALS & ALLOYS on one point. Eindhoven is not situated in Germany as was erroneously stated in a translation of the article by Sizoo and Zwikker, in METALS & ALLOYS, Vol. 1, No. 1, page 29, but in Holland.

The research was carried out at the famous physical laboratories of the Philips' Works.

As in every small country we have to publish the results of our work in, and to learn the advance of science from, foreign scientific and technical journals, principally German, English, French and Swedish papers. As to the American literature, being a member of the American Society for Steel Treating myself, I every month receive their transactions, which give a good idea of the present status of the knowledge of the properties of iron and steel in the United States. There was, however, till now no American periodical which gave a general view of the advancement of non-ferrous metallurgy and in this respect I believe that METALS & ALLOYS supplies a long felt want.

Of course, the translations from German and other journals and the review of current literature though very complete, have less value for me, as I see the original journals, but the articles on different subjects as well as the correlated abstracts, and, not the least, the book-reviews, are excellent. As far as I am concerned I hope that METALS & ALLOYS will give as much scientific and technical work as possible.

If I might suggest one thing to you, it would be to give now and then a description of the equipment, the scientific staff and their work, of the most important American research institutes and laboratories of which we read so much and know so little. Especially for your foreign readers this would be of greatest interest.

DR. P. SHOENMAKER

Willem Smit & Co., Ltd.,
Electrical Welding Department,
Nijmegen, Holland.

Editor's Note: The editorial staff has been laying plans for a series of articles along the lines suggested in the last paragraph, and hopes to start publication of the series in a few months.

Elasticity of Steel Pump Rods

The elastic properties of steel rods and their effect upon oil field pumping operations were investigated recently by H. E. Dralle, petroleum engineer, and M. Stone, research engineer, both of the Westinghouse Electric and Manufacturing Company.

Steel rods, each about 20′ long, screwed together and lowered into a well, support at the lower end a pump which moves up and down from 6–30 times a minute to bring oil to the surface. Because of the starting, stopping, raising and lowering of this string of rods and the long column of oil, each rod stretches a little. The top rod, of course, stretches the most because it supports the total weight, and the bottom rod stretches the least.

The slight stretching in each 20′ link, added together makes up the 1′ or more total. Stranger still, because of the elasticity, the top link in the pumping chain may be going up while the bottom one is going down, or vice versa, the engineers said.

Wire cables used in drilling act the same way, only worse. When the heavy drill burrows its way a mile or more into the ground, the wire line easily may stretch 10 or 12′.

Prize for New Uses for Mercury

"Mercurio Europeo," a group of producers of mercury, offers a prize for a new use of mercury which will cause a new consumption of at least 1000 flasks in 1933, 3000 in 1934 and 5000 per year thereafter. To be eligible, the use must be unknown to industry at present, and must be protected by a patent.

It seems rather unlikely that anyone could find, by individual experimentation, as is stipulated, a new use, and get a patent through the U. S. Patent Office, at least, in the time stipulated, and the Commission, which is to award the prize (made up of the President and Vice-president of Mercurio Europeo, and two technicians named respectively by the Spanish and Italian Academies of Science) may extend the competition another year.

If the Commission decides to award the prize, 1000 pounds sterling will be paid after the decision, and 2000 pounds sterling one year, and another 2000 two years later, if the povision as to consumption has been fulfilled. "The decision of the Commission is final without giving its reasons and is exempt from appeal."

Further information may be had from Mercurio Europeo, Place St. Francois 5, Lausanne, Switzerland.

It will be interesting to see whether any new use does result from the offering of a prize. It may turn out to be a cheap way of getting results as it may induce many workers to tackle the problems at their own expense, "on speculation," and Mercurio Europeo does not have to put up for salaries or expense, and if nothing results, it is not out anything.

We wonder how many workers will make some progress toward the goal, but run out of funds before they accomplish any real results.

It would appear more sensible to hire some scientists to develop various new uses, even though the increased consumption of mercury might not come up to the stipulated amount, and to finance promising investigations further than an individual can.

It's a "heads I win, tails I don't lose" proposition for the mercury producers, and seems to us to be going at the problem the wrong end to.—H. W. G.

Standards and Ossification

While the subject was airplane wheels rather than metals, some comments made by Cantley[1] upon standardization are so thoroughly sensible, that we pass them on to our readers. He says, "A standard, in the American automotive industry, of which airplanes are a part, is a tool to be worked with or discarded, not an idol to be made sacred and worshipped without logic or thought.

"Putting it another way, American standards are a target to be shot at and to be removed if they can be filled full of holes. Standards are set up for the economic advantage of an industry and unless they can prove their worth, they should be and are, discarded.

"In the basic sciences such as physics, basic laws or standards are set up and last usually a long time, until later research proves the necessity for modification. In industry, especially the newer ones such as aeronautics, standards are set up as signposts of the direction of economic manufacture and maintenance. Absolute individualism is as dangerous in industry as it is in government. On the other hand, slavish conformity and fear of change are even worse.

"The automobile industry in America has proved the value of fluid standards actively administered and watched over. It has proved equally clearly the fact that if standards are set up which are ill advised, or ahead of their time, they will not be used. Cancellation of poor standards is as important as the framing of proper ones. Fluidity of the standards system in new art is vital and if they are so regarded, they are a most important part of the economic structure, leading to reductions in costs, which are vital to success. "If they are kept static as in the case of less happily situated government agencies than those for air, they are a handicap which is sometimes almost fatal.

"Let us standardize in a fluid manner and advance; not in a solid manner and ossify. Let us truly standardize and progress."

---

[1] J. R. Cantley, "The Standardization of Airplane Wheels," *Aviation*, Vol. 28, February 22, 1930, pages 370–372.

The Structure of Heat-Treated Low Carbon Steel

By Welton J. Crook[1] and Howard S. Taylor[2]

Introduction

Much has been written regarding the structural changes which take place when specimens of the higher carbon steels are gradually heated up to and above their transformation ranges; much also has been recorded regarding the changes which take place when such steels are reheated or drawn after quenching. When the literature is consulted regarding the heat treatment of low carbon steels, a thorough discussion is available concerning the structural changes which occur on gradually heating normal low carbon steel; but very little is available concerning the mechanism of drawing such steel from the quenched state.

In connection with a study of the physical properties of heat treated low carbon steels which has been carried on for some years by one of the authors, it became necessary to arrive at some conception of the structural changes which take place when a steel containing about 0.20% carbon is quenched from just above the upper critical point and subjected to various draw temperatures. The investigation was undertaken from a practical, rather than from a strictly scientific, point of view. It was desired to find what micro-structures might be expected when the steel was heat treated on a commercial scale rather than to develop a scientific theory.

Experimental Procedure

The specimens used were cut from one thirty-foot length of $^3/_4''$ round bar of special bolt stock which was secured through the courtesy of the Pacific Coast Steel Company, San Francisco. The analysis was found to be as follows:

	%		%
Carbon	0.20	Silicon	0.13
Manganese	0.59	Copper	0.29
Phosphorus	0.016	Nickel	0.19
Sulphur	0.042	Chromium	Trace

The steel was made by the basic open hearth process, and was thoroughly killed with silicon before tapping.

It will be noticed that this steel contains both nickel and copper in measurable quantities. Practically all steel produced on the Pacific Coast and, for that matter, the majority of the steels produced in the United States, contains these elements in quantitative amounts. It is of interest to note that the proportions of both copper and nickel in steels produced in this country are gradually increasing because of the use of automobile scrap and the inability to remove copper and nickel from steel by any known commercial steel making process.

Reference to a complete list of the analyses of Standard Steel Samples, issued by the U. S. Bureau of Standards, will reveal the steady increase in copper and nickel content which has occurred in plain carbon steels as time has gone on.

Specific cases of high copper and nickel in Bureau of Standards standard plain carbon steel samples may be quoted as follows:

Copper and Nickel in Standard Steels

Steel No.	% Cu	% Ni	% Cu + Ni
13 C	0.165	0.196	0.361
20 C	0.255	0.181	0.436
34 A	0.222	0.232	0.454
30 B	0.130	0.282	0.412
35 A	0.267	0.254	0.521

The steel used in connection with the preparation of this paper was not copperized intentionally. The alloy content was simply residual from the metal charged to the furnace. The results of heat treatment are unaffected by the copper and nickel content, as shown by the normal position of the transformation points.

It may be objected, in spite of the above statements, that the steel used is nevertheless an alloy steel, especially in view of an editorial[3] appearing in *Iron Age* in which an "alloy steel" is defined as "a carefully made steel containing a substantial quantity of another metal intentionally added to improve the physical properties."

In consideration of the preceding discussion, the authors of this paper consider that the steel used in the experiments herein recorded should be classed as a plain carbon steel of commercial grade, although the editorial appearing in *Iron Age*, previously mentioned, suggests that the minimum content of alloy which should be present is as follows:

Manganese	1.0% (but not for Bessemer)
Silicon	0.3% (but not for castings)
Nickel	0.5%
Chromium	0.5%
Molybdenum	0.25%
Tungsten	1.00%
Vanadium	0.15%
Aluminum	0.5%
Copper	0.25%

According to this suggestion, the steel in question exceeds the minimum (0.25%) by 0.04%, and on this ground might be considered an alloy steel.

The transformation points were determined by means of a Leeds and Northrup's Standard Potentiometer, a Brown Transformation Point Recorder, and a Rockwell Dilatometer equipped to record temperatures, and found to occur as follows:

Ac_1 = 1342° F. (729° C.)
Ac_2 = 1490° F. (809° C.)
Ac_3 = 1530° F. (831° C.)

Test specimens were prepared by cutting off sections, from the original bar, $1^1/_4''$ (32 mm.) long. One-eighth inch was then milled off each side of the specimen in order to obtain flat surfaces for hardness tests. The machined specimens measured $1^1/_4''$ by $^3/_4''$ by $^1/_2''$.

A series of the bars were subjected to a "regeneration test" by heating for 30 minutes at temperatures beginning at 1300° F. (740° C.) and increasing by increments of 50 – 1700° F. (926° C.). After heating for the proper time at temperature, the specimens were quenched in cold water at 650° F. The heating was done in an automatically controlled electric muffle furnace. The temperatures recorded are within ± 50° F. of the actual temperatures.

Table I—Regeneration Hardness

Quench Temperature ° F.	Quench Temperature ° C.	Brinell Hardness 10 mm. ball. 3000 Kg. load
Original	...	143
1300	704	202
1350	734	269
1400	760	269
1450	787	444
1500	815	444
1550	842	444
1600	871	444
1650	898	262
1700	926	360

Regeneration curves, of the majority of low carbon steels which have been observed, showed a gradual increase in hardness until the upper critical temperature was reached and then fell off sharply as this temperature was exceeded. The

---

[1] Professor of Metallurgy, Department of Mining Engineering, Stanford University, California.
[2] Instructor, Department of Mining Engineering, Stanford University, California.

[3] "What Is an Alloy Steel," Editorial, *Iron Age*, March 7, 1929, page 690.

curve, for the steel under discussion, is somewhat abnormal in that (a) it reaches a maximum at a temperature well below the upper critical temperature, and (b) it shows a secondary maximum hardness at 1700° F. (926° C.). Similar occurrences have been noticed previously, but no explanation of the matter is at hand.

Structural Changes on Heating

As previously stated, the structural changes which occur in low carbon steel, when it is heated gradually, have been described fully in the literature. Sauveur[4] discusses these changes from two points of view; namely, (a) that solid solution (austenite) is formed just above the A_1 point, and (b) that troostite forms above the A_1 point and is transformed to martensite at the A_2 point; austenite not forming until the A_3 point is passed.

In order to clear up the points of difference between these two views, the specimens from which the regeneration tests were made were examined microscopically. The structures found are shown in Fig. 1. Examination of the diagram, which is part of Fig. 1, discloses that at 1300° F. (704° C.), the original pearlite areas have undergone some change, although the temperature is below the Ac_1 point. The pearlite laminae are no longer clearly defined, and a slight tendency towards martensitization is shown. This is reflected in an increase in Brinell hardness. When 1350° F. (734° C.) is reached, the pearlite has completely disappeared and its original areas are replaced by a typical martensitic structure. As the temperature is increased to 1450° F. (787° C.), the martensite areas increase in size as ferrite is absorbed or, we may say, as the carbon migrates or diffuses. In this way the martensite becomes more and more dilute in carbon. The grain structure of the martensite itself also shows a distinct and progressive coarsening as it is heated more and more above the lower critical point.

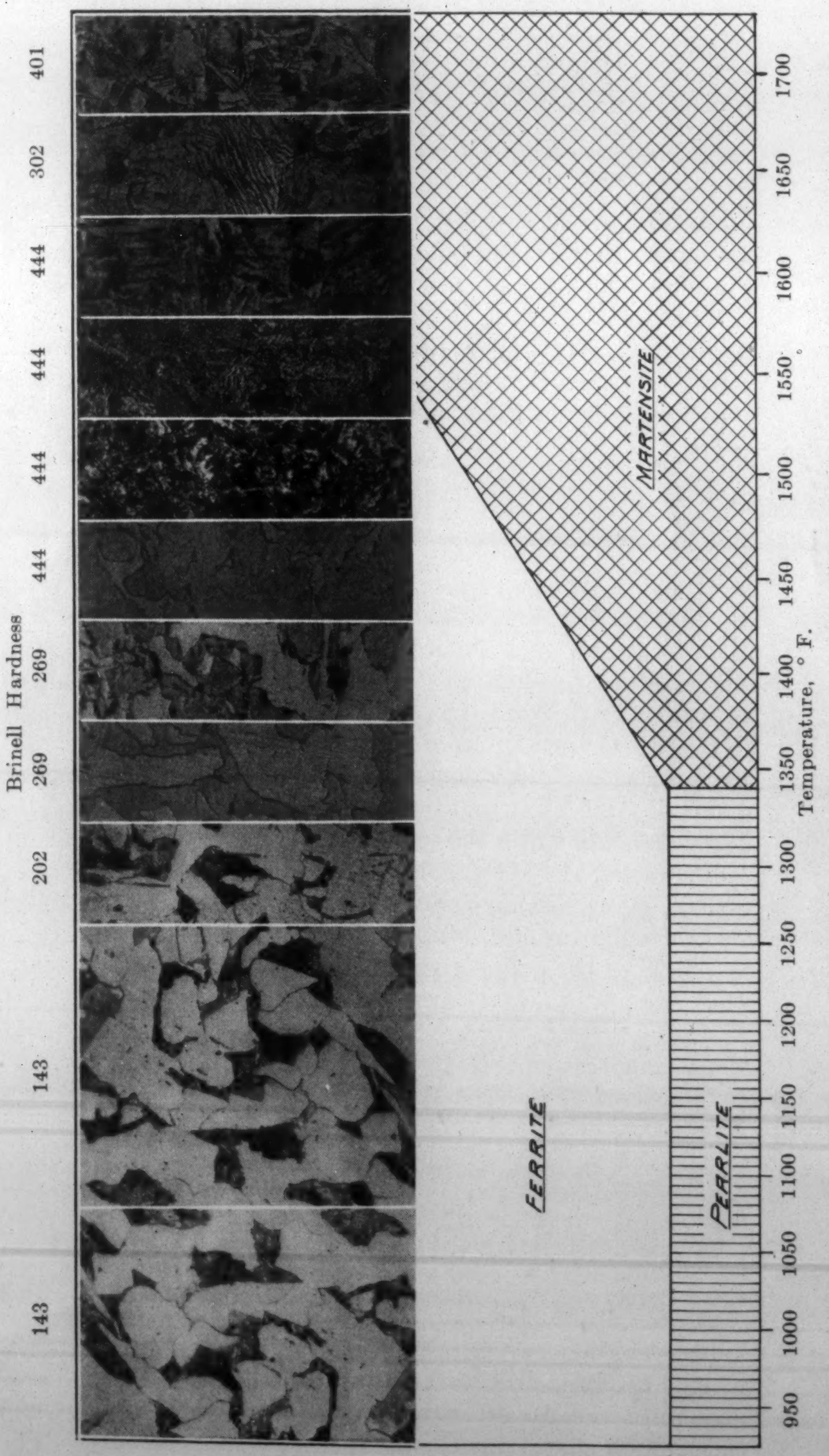

Fig. 1—Quench Structure of 0.20% Carbon Steel. Original Micrographs. 1000 ×—Reduced 1/2

At a temperature between 1450° F. (787° C.) and 1500° F. (815° C.) an abrupt change in structure occurs, the martensite produced by quenching from 1500° F. (815° C.) having an entirely different appearance from that produced by quenching at 50° F. lower temperature. This point of change apparently coincides approximately with the Ac_2 point, which was determined to be at 1462° F. (793° C.).

Except for the fact that well established modern theory points to a contrary conclusion, this might be interpreted to mean that when the steel is heated at temperatures above Ac_1 and below Ac_2, the carbon bearing areas are changed to martensite which is retained on quenching in cold water. On the other hand, if the temperature exceeds the Ac_2 point, the carbon bearing areas are changed through martensite to austenite, and a recrystallization takes place in so doing. Water quenching, however, is not sufficiently fast to retain the austenitic structure, so that a martensitic structure of a different form is observed. This is shown, in Fig. 1, in the specimens quenched from 1450° F. (787° C.) and from 1500° F. (815° C.). The mechanism described agrees to some extent with Sauveur's second hypothesis, since the martensite observed after quenching might be either martensite that existed as such before the quench or that formed from austenite; this is not, however, a definite proof of the correctness of Sauveur's second hypothesis, but the authors believe that since no sign of troostite transformation was found, the possibility of direct transformation of pearlite to martensite deserves more attention than is ordinarily paid to it.

At 1550° F. (842° C.), the ferrite appears to be completely in solution and the steel as a whole exhibits the smallest average grain texture on quenching. The Ac_3 point was determined as being at 1530° F. (831° C.). As the quench temperature is carried above the Ac_3 point, the martensite retained on quenching assumes a coarser and coarser texture and generally exhibits a progressive falling off in hardness. The reason for this progressive decrease in hardness, as the quench temperature is increased over the upper critical point, is possibly caused by the formation of larger and larger crystals which possess less and less so-called "amorphous material" per unit area. There may be an analogy between this condition and the well-known difference in hardness, with constant chemical composition, which exists in fine grained steel and steel having a large grain size. The speed of quenching from the higher temperature may prevent the deposit of minute Fe_3C particles which, as Jeffries and Archer show, tend toward harder material.

Structural Changes on Reheating Quenched Steel

In order to study the micro-structural changes which take place when quenched (martensitic) low carbon steel is reheated or drawn, a number of specimens, similar to those previously used, were heated for 30 minutes at 1550° F. (842° C.) and water quenched. As a check on the uniformity of heat treatment, each specimen was tested for hardness and found to be 444 Brinell.

To successfully carry out a study of the changes on drawing the quenched steel, it was necessary to obtain some idea of the time equilibrium at the various draw temperatures. A series of test specimens were heated for various times and at various temperatures between 300° F. (165° C.) and 1300° F. (704° C.), and then tested for Brinell Hardness.

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[4] A. Sauveur, "The Metallography and Heat Treatment of Iron and Steel," 3rd Edition.

Table II—Equilibrium Temperatures

Draw Temperature		Brinell Hardness after heating for minutes indicated							
° F.	° C.	10	20	30	45	60	120	180	540
300	149					444	444	444	444
550	288			401	401	401			
800	426			321	321	321			
1050	565		261	248	248				
1300	704	196	196	179					

From the results of these tests, it was considered that the times at drawing temperature shown in Table III were sufficient to estabish structural equilibrium for all practical purposes.

Specimens of the steel, which had been water quenched from 1550° F. (842° C.), were drawn at various temperatures, starting with 450° F. (232° C.) and increasing by increments of 50° F. After drawing, the specimens were tested for hardness and examined microscopically.

Table III—Drawing of Quenched Steel

Draw Temperature ° F.	° C.	Time at draw Temp. in min.	Brinell Hardness
450	232	75	435
500	260	60	401
550	288	45	401
600	315	30	388
650	343	30	375
700	371	30	363
750	399	30	341
800	426	30	321
850	454	30	311
900	482	30	302
950	510	30	285
1000	538	30	269
1050	565	30	248
1100	593	30	241
1150	620	30	223
1200	648	30	217
1250	675	30	207
1300	704	30	179
1375	744	30	133

(The tabulated results are shown graphically in Fig. 2.)

The micro-structures of the steel after drawing at various temperatures are shown in Fig. 3. As shown by the hardness and micro-structure, the steel after drawing at 450° F. (232° C.) is mainly martensitic. The structure of the specimen drawn at 1375° F. consists plainly of spheroidal cementite and ferrite, even though the time at temperature was shorter than is usually supposed to be required for spheroidization. Lucas[5] however, showed that complete spheroidization of 0.9% carbon steel could take place in ten minutes at 1112° F. We have, then, at one end of the temperature range, martensite and at the other, ferrite and cementite. The question arises as to the mechanism of transformation. According to Jeffries and Archer[6] martensite consists of very fine grained alpha iron containing carbon atomically dispersed, but not in true or stable solid solution. Troostite and sorbite also consist of alpha iron and differ from martensite only in that ferrite grains and cementite particles are larger in size, those of the sorbite being larger than the others.

This theory appears to be borne out when the photographs shown in Fig. 3 are studied, except that the grain size of the ferrite produced by a high draw does not seem to be materially larger than that of the grain size of the original martensite. This is well illustrated by the fact that if great care was not taken in etching the specimen drawn at 1200° F., the structure produced was difficult to differentiate from that existing in a specimen drawn at 600° F.

There seems to be no evidence that the steel passes through the stage of troostite. According to Jeffries and Archer[7] "There is a marked difference between the etching characteristics of martensite and troostite and between martensite and austenite. Martensite is more resistant to acid attack than troostite, but less resistant than austenite." Following out the theory that the difference between martensite and troostite is simply a size condition of cementite particles, they say, "In

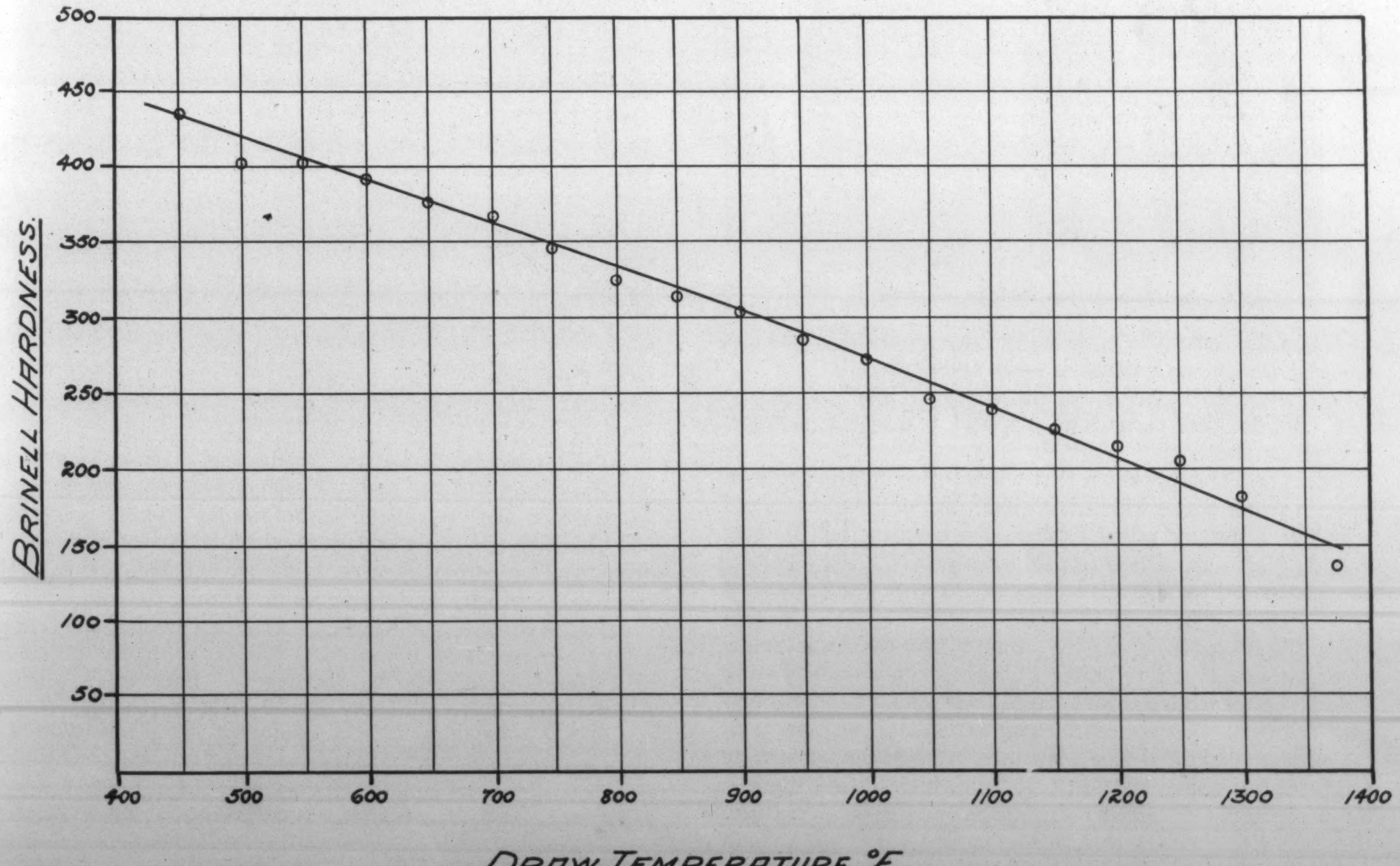

Fig. 2—Draw Temperature-Hardness Curve. 0.20% Carbon Steel

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[5] *Transactions American Society Steel Treating*, Feb. 1929, page 361.

[6] Z. Jeffries and R. S. Archer, "The Science of Metals," Chapter XII, 1924.

[7] See Reference 6, page 430.

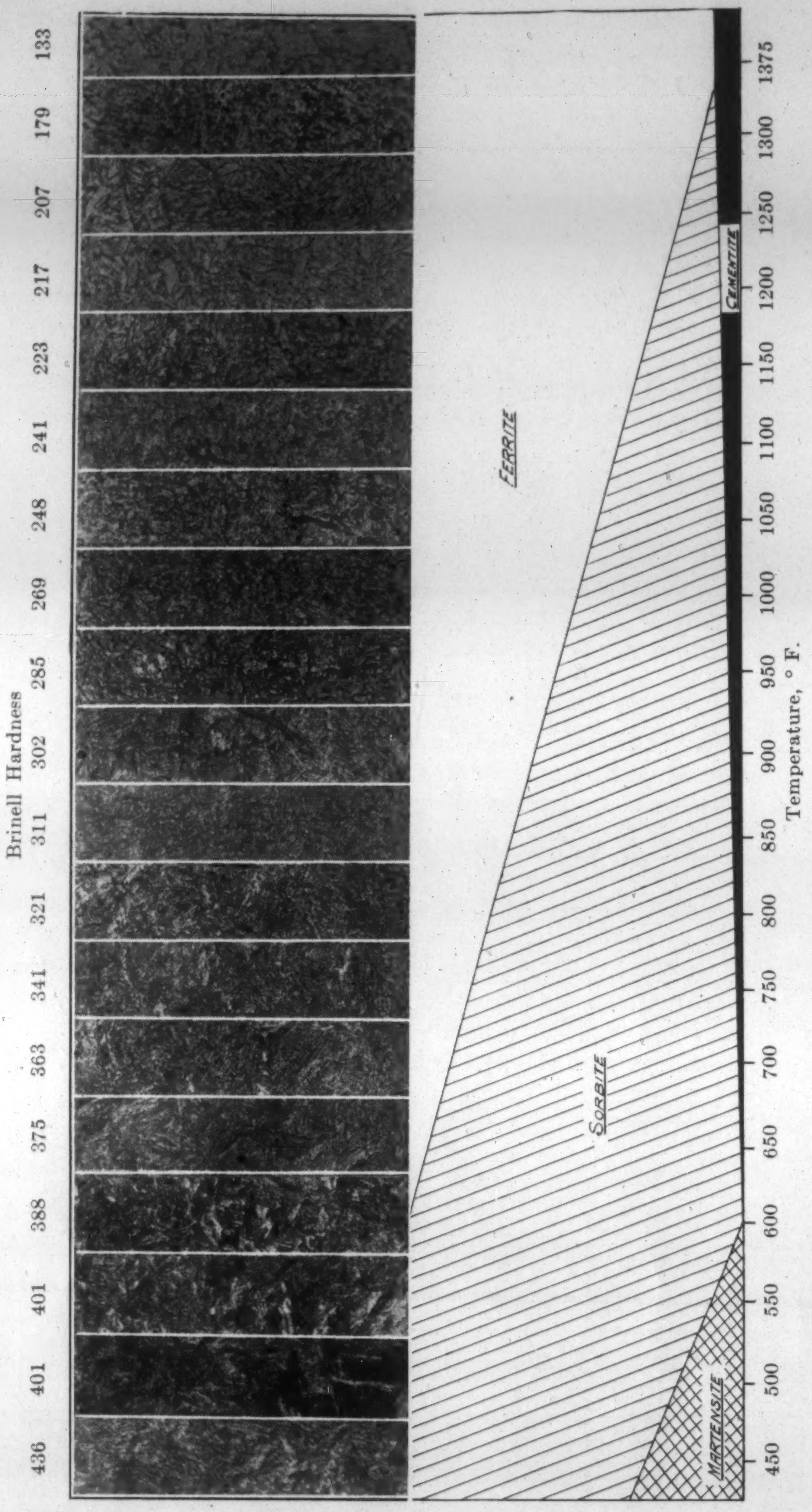

Fig. 3—Effect of Draw Temperature on Quenched 0.2% Carbon Steel. Original Micrographs 1000 ×—Reduced 1/3

troostite the cementite particles are super-critical in size and the etch or corrosive attack is more pronounced."

It is apparent that the etching effect, commonly known as troostite, does not occur to any appreciable extent in drawn low carbon steel.

Based on the supposition that when the cementite particles have reached a size which is visible, say, at 1000 mag., and which is generally called "spheroidized cementite," a corresponding amount of free ferrite has been produced, the diagram attached to Fig. 3 is suggested. In such a diagram, it is necessary to indicate the temperature at which the free cementite makes itself visible. A number of the drawn specimens, whose structure, after "nital" etching are shown in Fig. 3, were repolished and treated with boiling sodium picrate solution. Very careful examination at one thousand magnification showed free cementite in specimens drawn at temperatures above 600° F. (315° C.), but did not disclose its presence in specimens drawn below this temperature. (See Fig. 4.)

The temperature at which the transformation from sorbite to ferrite and cementite begins was therefore placed at 600° F. (315° C.). The suggested transformation diagram is based entirely on a practical point of view and on a limiting visibility at one thousand magnification.

Micro-structural Changes on Drawing

The suggested mechanism of transformation, which takes place when quenched martensitic low carbon steel is subjected to increasing draw temperatures, is as follows:

(*a*) Low carbon martensite.
(*b*) At a low draw temperature, probably a little above 212° F. (100° C.), martensite begins to transform to sorbite.
(*c*) At 600° F. (315° C.), free spheroidal cementite appears (at 1000 magnification) with the probable formation of a corresponding proportion of free ferrite.
(*d*) As the draw temperature is increased, more and more spheroidal cementite and free ferrite appears with a corresponding diminution of the sorbite.
(*e*) At about 1340° F. (726° C.), the steel consists only of free cementite and free ferrite.

It should be understood that the particular steel under discussion is one which has been well deoxidized in the process of manufacture, and contains sufficient manganese so that it is capable of assuming complete "regeneration" when heated above the upper critical range. In other words, when the steel is water quenched from above the Ac_3 point, a complete martensitic structure is retained.

Many low carbon steels, having a manganese content below 0.50% and especially those which have not been thoroughly deoxidized in the process of manufacture, will not completely retain a complete martensitic structure on quenching from above the Ac_3 point.

It is possible that such steels will show a completely different reaction on drawing. The quenched structure may consist of martensite and ferrite, and the martensitic areas may pass through a distinct troostitic transformation. Many tests have shown that steels which fail to regenerate cannot be greatly benefited physically by any ordinary method of heat treatment.

Jeffries and Archer[8] state, "The hardness of low carbon steels is known to be not greatly changed by tempering, and the changes brought about by tempering above 500° C. are certainly in the direction of softening."

In this regard, it may be pointed out that properly deoxidized low carbon steels containing over 0.50% manganese are capable of assuming a quenched hardness up to 600 Brinell. Paine,[9] working under suggestions of one of the authors, was able to produce specimens of heat treated low carbon steel (carbon, 0.24%; manganese, 0.75%) which resisted penetration of 0.30 calibre armor piercing bullets at a range of 100 yards. When such steels are tempered or drawn, they exhibit a uniform and progressive softening as the drawing temperatures are increased.

Summary and Conclusions

(a) The structural changes which take place on drawing quenched low carbon steel have received little attention. An attempt has been made to determine, from a practical point of view, the micro-structure which is developed when a deoxidized low carbon steel containing over 0.50% manganese is subjected to various drawing temperatures.

(b) It is possible that when a low carbon steel of the character described in (a) is heated to the Ac_1 point, the pearlite may transform directly to martensite. Between Ac_1 and Ac_2, the martensite gradually absorbs free ferrite and is retained, on quenching, as low carbon martensite. When a temperature above the Ac_2 point is reached the carbon bearing areas are converted to austenite, and are recrystallized in so doing. On quenching the steel from a temperature between

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[8] See Reference 6, page 432.

[9] Roy E. Paine, "Armor Plate," *Army Ordnance*, Jan.-Feb., 1930, pages 239-247.

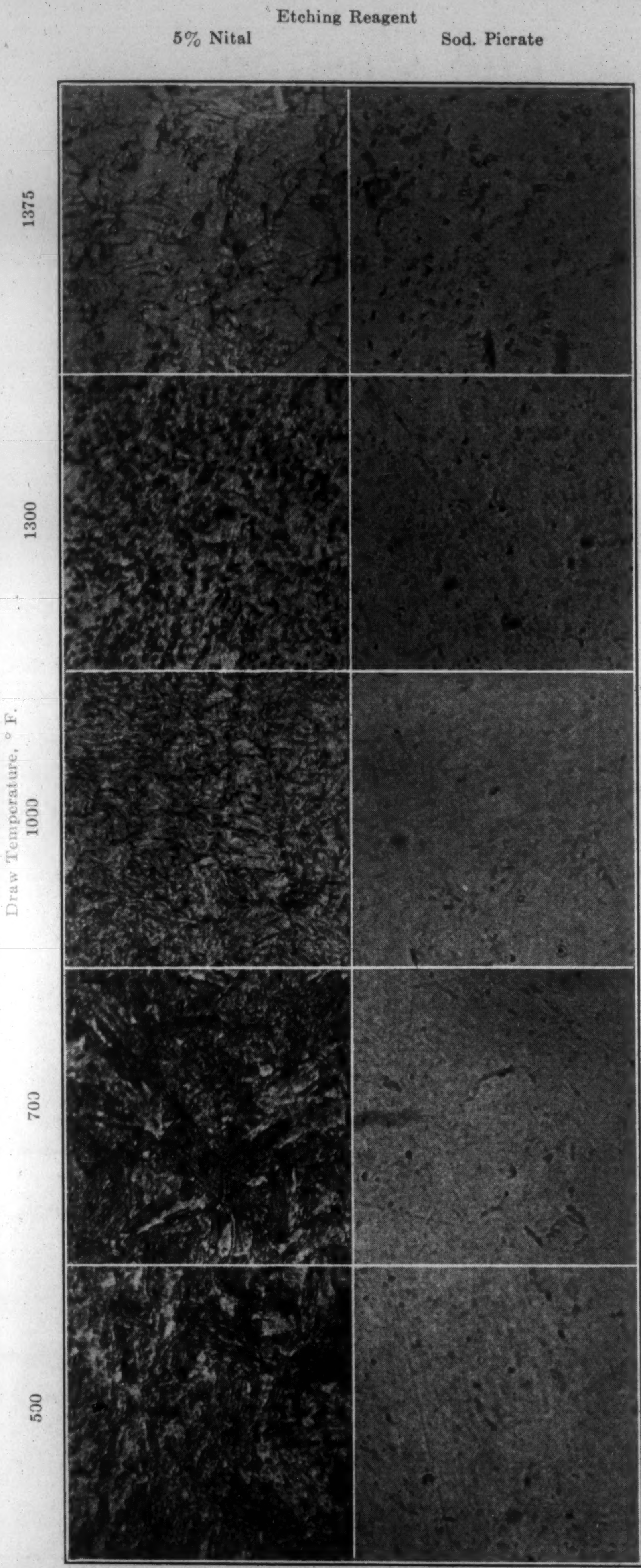

Fig. 4—Effect of Draw Temperature on Low Carbon Steel. Original Micrographs. 1000 ×—Reduced 36.8%

Ac_2 and Ac_3, the austenite is not retained but remains in the quenched steel as crystallized martensite.

It is recognized that the direct transformation of pearlite to martensite, on heating, is contrary to the generally accepted theory and that the experiments herein described do not offer conclusive evidence of such a direct transformation. The possibility of a direct transformation should, however, receive some consideration.

(c) Completely drawn, quenched low carbon steel (which is capable of regeneration) consists of ferrite and spheroidal cementite.

(d) The mechanism of drawing from martensite to ferrite and cementite is found to be (I) martensite to sorbite, beginning probably at 210° F. (100° C.); (II) at 600° F. (315° C.), completely sorbite; (III) as the draw temperatures are increased above 600° F. (315° C.), the gradual rejection of spheroidal cementite, formation of free ferrite, and gradual disappearance of sorbite; (IV) at the upper critical point the last of the sorbite has disappeared, leaving ferrite and spheroidal cementite.

(e) The hardness-temperature of draw curve shows a gradual and uniform decrease in hardness as the draw temperature is increased. No sudden changes in hardness were found to occur which indicated a gradual transformation of microconstituents.

Personals

E. A. Doyle, consulting engineer of the Linde Air Products Company was elected President of the American Welding Society at the annual meeting of the society held April 25, 1930.

Dr. Robert J. Anderson has resigned as Vice president and director of the Fairmont Aluminum Company of Fairmont, W. Va. His future plans will be announced at a later date.

Frank M. Smith
President
Northwest Lead Co.

Mr. Frank M. Smith, Vice-President of Northwest Lead Company, Seattle, Wash., since 1920, was recently elected President to succeed Mr. John T. Lund, who resigned due to failing health. Other new executive officers are Vice-President, Treasurer and General Manager, Roger H. Cutting; Vice-President and Production Superintendent, J. A. McDonald; Secretary and Northwest District Sales Manager, John R. Owen.

Mr. Smith is also Smelter Director for the Bunker Hill & Sullivan M. & C. Co., Metallurgical Engineer for Treadwell Yukon Co., Ltd., past Vice-President of the A. I. M. E., member of the Mining & Metallurgical Society of America and Past President of the Northwest Mining Association.

Dr. L. J. Weinstein, prominent in dental circles, active in cooperation with the Bureau of Standards in its work on metallurgical and other materials for dental purposes, and recently appointed to the staff of Northwestern University, died of pneumonia on May 14th.

The Connersville Blower Company, Inc., of Connersville, Indiana, has moved its Chicago Sales Office to Room 1428, 20 North Wacker Drive. Also, their New York Sales Office is now located at Room 533 of the Graybar Building, 420 Lexington Avenue.

St. John X-ray Service is the name of the corporation recently organized by Ancel St. John and Herbert R. Isenburger with offices at 505 Fifth Ave., New York, to carry on the X-ray inspection and sales business formerly conducted by them as individuals.

Federated Metals Corporation has moved its offices to 295 Madison Ave., New York.

Climax Molybdenum Company is now in its new offices at 295 Madison Ave., New York.

Plans for an **American Meeting** to be held by the British Institute of Metals in the United States and Canada two years hence, are now taking definite shape. The Reception Committee of the Institute's hosts in the United States—the American Institute of Mining and Metallurgical Engineers—has prepared such an attractive program that nearly 100 British members have already booked for the trip. The visit will include official meetings of the Institute in New York, and joint meetings with allied societies in Detroit and Toronto. Other cities in the itinerary include Pittsburgh, Cleveland, Chicago, Niagara and Montreal, where plants will be visited. The party is expected to leave Southampton on September 3, 1932. The meeting in New York will begin on September 11, and the return journey will start from Montreal on September 30.

Modern Zinc Base Die Casting

By W. M. Peirce*

> *Volume for volume, a zinc-base die casting is the cheapest non-rusting metallic material available.*
>
> *Die casting forms the metal so close to required dimensions that machining costs are negligible. Hence, where a strength of 50,000 lbs./in.^{2} with rather low ductility, will do, zinc base die castings are one of the most attractive metallic materials we have.*
>
> *Their importance is recognized by the attention given them by the Die Casting Committee of the A. S. T. M. which has in hand a huge experimental project covering over 60,000 test specimens aimed at the standardization and improvement of die castings.*
>
> *This work has shown an almost revolutionary improvement due to the use of the purest zinc. Apparently zinc of 99.99% purity is none too good for die castings, and the call for die castings bids fair to bring forth increasing quantities of very pure zinc made by various methods.*
>
> *Metallurgists differ as to details of the mechanism of the transformations involved in aging, as to the causes and control of dimensional changes and as to the effect of impurities.*
>
> *Zinc die castings are not only important to the user as a cheap and useful, material, but also to the zinc producer as a potential means of increasing the market for zinc, a matter of moment in the present depressed state of the zinc industry. Further research on and development of die castings is highly desirable. The author of this paper is an outstanding authority in this field.*

Introduction.—The adjective, modern, has been purposely used in the title of this article. Progress has been so rapid in recent years that many engineers and metallurgists are not acquainted with developments which have radically changed the status of die cast alloyed zinc as an engineering material.

The fascinating ingenuity which is shown in modern casting machines, some of which are completely automatic, and in dies, which turn out the most intricate parts in a single operation, has been ably pictured by several writers. But progress has been equally dependent on the improvement in alloys suitable for die casting. The purpose of this article is to point out the problems which are involved in securing a suitable alloy and the advances which have been made in perfecting zinc base alloys for die casting.

Requirements of a Die Casting Alloy.—The mechanical nature of the die casting process places certain requirements on the alloys which are employed. First of all, it must be possible to hold the molten alloy in the iron melting pot of the die casting machine for some time without having contamination occur to such an extent as to affect the properties of the alloy. Second, a high degree of fluidity is required to secure sound castings with the perfection of finish which is usually necessary. Third, the alloy should be quite free from hot shortness since it must be cast in a water-cooled steel mold where the shrinkage strains are serious. Finally, the finished castings must have such properties of strength, ductility, resistance to impact, and corrosion resistance that they can be used where the requirements in respect to these various properties are very severe.

Zinc Base Alloys.—It is not impossible to die cast pure zinc but the attack on the iron parts of the die casting machine by pure zinc is inconveniently rapid. Zinc alloys, containing aluminum even in such small amounts as a quarter of a percent, wet and attack iron much less readily than pure zinc. The fluidity of pure zinc is also somewhat unsatisfactory for die casting. This condition may also be improved by alloying with aluminum in amounts ranging from 3–15% or with from 5–10% of tin. Finally, the physical properties of pure zinc are inadequate for many uses where considerable strength is required. Copper in amounts ranging from 2–4% or 5% has some strengthening effect but aluminum is by far the most effective alloying element for improving the strength of zinc.

For certain reasons, a type of alloy, ordinarily containing about 6% of tin, 4% of copper, and $^1/_4$–$^1/_2$% of aluminum, was the most satisfactory alloy in use for some years. It was handicapped by its relatively high cost, due to the tin content; its hot shortness, also due to the tin; and its low tensile and impact strength. During the past seven or eight years the trend has been very strongly toward the type of alloy containing 4% of aluminum, 3% of copper, and frequently 0.1% magnesium and balance high grade zinc. Care is taken to avoid contamination by tin which is apt to occur in a die casting plant where other alloys are handled. This type of alloy is characterized by a high tensile strength (40,000–50,000 lbs./in.^{2}), good impact strength and other desirable qualities.

The Zinc Aluminum Alloy System.—To study the physical metallurgy of the type of alloy containing 4% of aluminum, it is necessary to consider first the binary system zinc–aluminum.

Somewhat less than 1% of aluminum enters into solid solution with zinc to form a homogeneous alloy consisting of a single phase known as the alpha phase. Zinc added to aluminum in amounts up to the neighborhood of 20% enters into solid solution to form a homogeneous alloy consisting of a gamma phase. Zinc aluminum alloys containing from 1–21% aluminum, between the freezing point and about 270° C., consist of a eutectic of alpha and a new phase or constituent known as beta together with an excess of alpha, if the aluminum content is less than 5%, or of beta, if the aluminum content is above 5%.

At a temperature of about 270° C. this beta constituent is transformed into a mixture of alpha and gamma. This transformation is accompanied by a decrease in volume and an evolution of heat. In the pure zinc aluminum alloys, the transformation is extremely rapid. Because of the rapidity with which this volume decrease occurs, the stresses set up within the alloy structure are severe and are reflected in the final properties of the metal possibly through the formation of some microscopic cracks at certain of the boundaries.

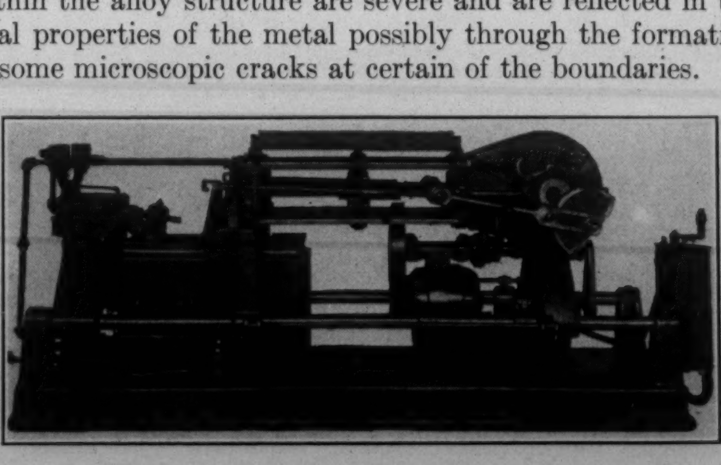

Fig. 1—One Type of Modern Automatic Die Casting Machine

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* Chief of Metal Research Division, The New Jersey Zinc Co.

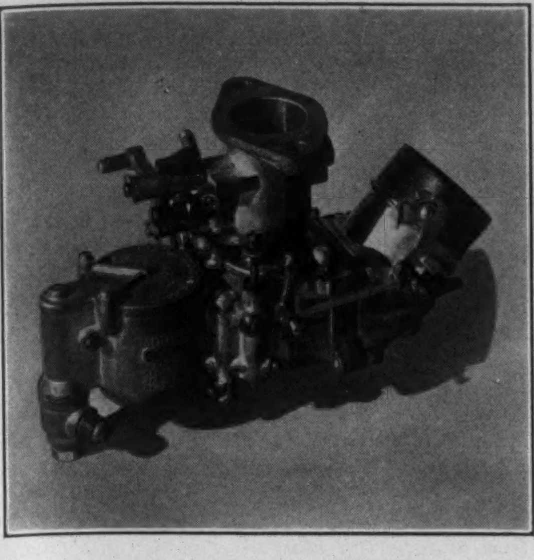

Fig. 2—A Modern Zinc Base Carburetor. The Machining and Number of Parts Are Reduced to a Minimum by the Use of Die Castings

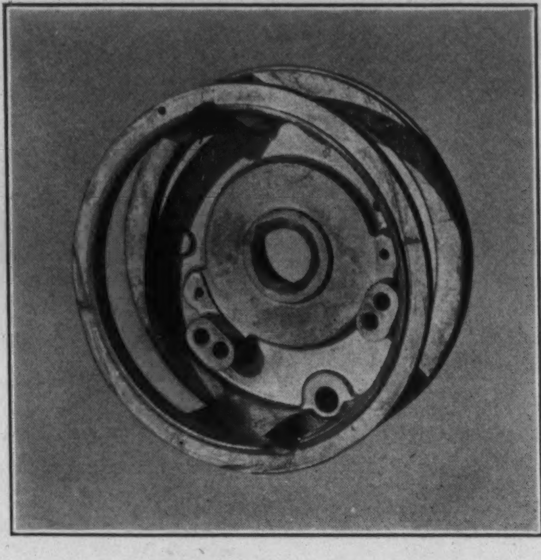

Fig. 3—Another Zinc Base Die Casting Which Saves Machining Costs

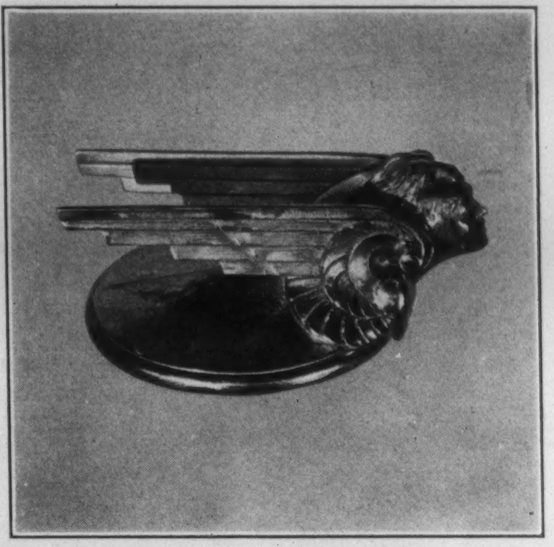

Fig. 4—Intricate Ornamental Designs Are Perfectly Reproduced at Moderate Cost

Certain elements, notably copper, magnesium and nickel, which may be added to these alloys, have a very pronounced effect on the rate of transformation and hence on the resulting properties of the alloys. The presence of 3% of copper in an alloy containing 4% of aluminum prevents the transformation from occurring immediately in chill cast alloys. The transformation, however, does occur slowly at room temperature, perhaps requiring several years to become complete. The addition of magnesium and nickel, either separately or together, further affect the rate in an advantageous manner, as judged by the properties of the alloys.

The Corrosion of Aluminum Zinc Alloys.—In many metals and alloys, if not in all, the grain boundaries are more susceptible to corrosion attack than the grains themselves. This effect is exaggerated in some alloys to a point where the metal may be completely penetrated along the grain boundaries by the corrosive attack before even the surface grains are completely corroded. This type of corrosion is referred to as intercrystalline corrosion or intercrystalline oxidation. In some of the aluminum zinc alloys, which were used in the early history of zinc base die casting, conditions of high humidity and high atmospheric temperature produced a severe type of intercrystalline oxidation which rendered them totally unsuitable for most purposes. In the modern zinc base die casting alloys, when a proper composition is chosen and high grade zinc used, intercrystalline oxidation may be reduced to a point where it is no longer of practical importance.

When the difficulties with early zinc base die castings were first diagnosed as resulting from the effect of high humidity and high atmospheric temperature, exposure to an atmosphere saturated with moisture at about 95° C. was rather generally adopted as a rapid means of determining the relative resistance of different alloys to intercrystalline oxidation. This test has served a useful purpose in the development of the present satisfactory alloys. It is nevertheless necessary to interject a word of warning against the use of this test indiscriminately as a means of determining the service life or general resistance to corrosion of zinc base die casting alloys or other materials.

The best zinc base die casting alloys are not immune to corrosion of a normal or surface type by steam nor are many of the other metals and non-metallic materials, with which they compete. The use of the steam test as a means of predicting service life should, therefore, be confined to parts that are to be used under similar conditions of temperature and humidity.

Changes in the physical properties of these alloys which occur during exposure to moisture and elevated temperature are, in the case of modern alloys, due rather more to the effect of temperature alone than to any surface corrosion which may occur. This will be more fully discussed in the next section.

Heat Treatment of Zinc Base Die Casting Alloys.—It was mentioned in connection with the constitution of the aluminum–zinc system that the transformation of beta into alpha and gamma is enormously retarded in chill cast alloys by the presence of copper and other elements in addition to aluminum; in other words, finished die castings of these alloys contain beta which in the course of a few years at ordinary atmospheric temperatures or in the course of a few days at 100° C. or of even shorter periods at higher temperatures is converted into alpha and gamma. This change is accompanied by a slight change in dimensions which calculation verified by long experience has proven negligible in the wide range of parts which are die cast. The physical properties also undergo some change in the direction of a small decrease in tensile strength and a decrease in impact strength. That these changes are due to the reversible beta transformation and not to corrosion of any character is evidenced by the fact that the original properties of aged specimens may be restored by reheating to above the transformation temperature and cooling rapidly.

These facts at once suggest to the metallurgist the possibility of heat treating these alloys to bring about the beta transformation with its accompanying dimensional change before the castings are put into use. This is actually possible in certain cases at least. There is another factor, however, that has a bearing on this matter. As in other alloys which owe their properties to a highly dispersed phase, the properties are influenced by the size of the dispersed particles and this size depends possibly on the rate at which the particles have been precipitated and certainly upon the length of time that the alloy has been exposed to a temperature where growth of the particles can occur. This explains the reason why rapid artificial aging treatments, which complete the beta transformation, do not yield the same final properties as aging at room temperature. As a matter of fact the properties secured by the best rapid aging treatment so far developed are inferior to the properties which the alloys have after five or six years aging under normal conditions. On the other hand, artificial aging treatments are possible which will give better final properties than aging at a temperature of 100° C., a condition which may occur in certain types of service to which die castings are subjected. Where die castings are designed for such service there is a possible advantage in a heat treatment which takes the form of cooling at a slow and controlled rate from above the transformation temperature to a point 25 or 50° below this temperature.

It must be pointed out that there are certain dangers connected with heating castings to above the transformation temperature of 270° C. The alloys are more easily deformed at that temperature and the castings must be handled with reasonable care. Moreover, especially sound castings are required for this purpose since large pockets of air entrapped under high pressure, which may occur when die design is poor, may cause the castings to blister when heated to above the transformation temperature. Thus, while heat treatment offers possible advantages for special cases, it must be undertaken with some care and under competent metallurgical supervision.

Microscopy.—The microscopic study of the structure of these alloys has not furnished information of especial value, since the important questions relate to the structure of the mixture of alpha and gamma resulting from the transformation of beta and this structure has proven too fine to resolve by the usual microscopic methods.

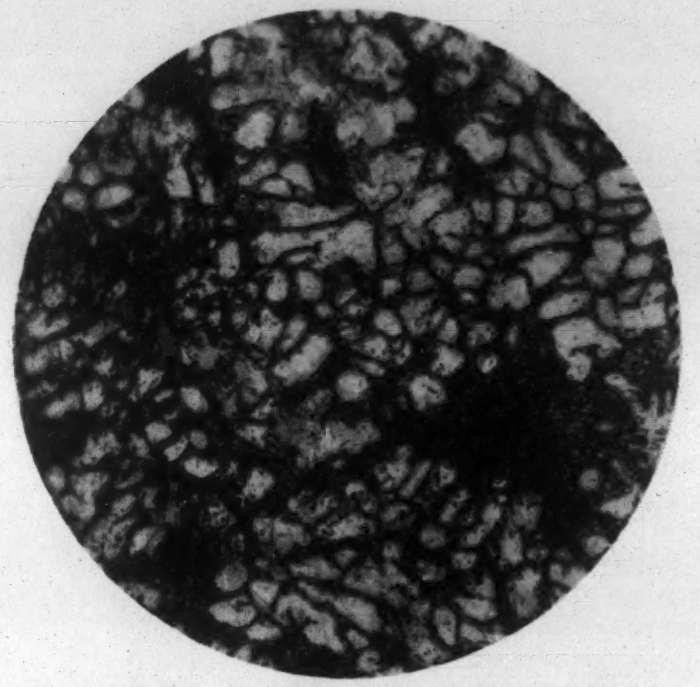

Fig. 5—Specimen of 4% Al, 3% Cu, 0.1% Mg Alloy Die Cast in a Hot Die. The White Constituent Is Alpha, a Solid Solution of Copper and Aluminum in Zinc. The Matrix Is a Eutectic of Alpha (Light) and Beta, a Zinc Aluminum Compound or Solid Solution (Dark). It is the Transformation of This Dark Constituent to Alpha and Gamma which Principally Accounts for Aging Changes. Magnification 500 Diam.; Etchant. 20 gm. Cr_2O_3, 3 gm. Na_2SO_4 Anhyd., 100 cc. H_2O

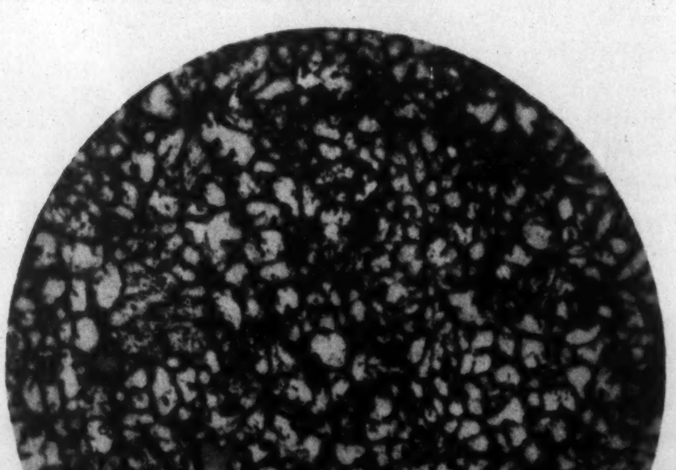

Fig. 6—Specimen of 4% Al, 3% Cu, 0.1% Mg Alloy Die Cast in a Cool Die. Gray Constituent Probably a Copper Rich Phase. Other Details Same as Fig. 5

The microstructure can, of course, yield some information as to the degree of chilling and hence offers a check on the casting conditions. Beyond this, microscopic examination of the alloys does not appear to be of great value as a control method. A few typical photomicrographs are included as a matter of general interest.

Conclusion.—Early steps in the improvement of zinc base die casting alloys were largely a result of "cut and try" methods. Later progress has been more intelligently guided by increased fundamental information on the constitution of the alloys and further advances may be expected as this knowledge is broadened and applied.

Markets for Zinc

One session of the meeting of the American Zinc Institute at St. Louis, April 15, was devoted to the above subject. R. M. Curts, New Jersey Zinc Company, discussed Zinc in Die-Casting, the talk covering much the same ground as a paper by W. M. Peirce, which appears on page 544 of this issue of METALS & ALLOYS. Mr. Curts emphasized the possibilities for increased use of zinc in die castings that will result from the trend toward the use of white metals and toward artistic design, in hardware, since zinc base die castings can be made more cheaply than most other alloys can be formed by any process. This paper indicated the type of research being carried on by one producer of high grade zinc.

H. W. Gillett, Battelle Memorial Institute, spoke on the Value of Research in Non-Ferrous Metals, citing the aluminum and the nickel industries as outstanding examples of the extension of markets by first finding out what the fundamental properties of the alloys were, improving them by research, and then finding uses for which the fundamental properties of the alloys fitted them to serve better than competing alloys. He thought that, with a few notable exceptions, the zinc producers had so far trusted chiefly to the users of zinc to determine the properties, improve the alloys and find the uses.

G. A. Charls, President, National Association of Flat Rolled Steel Manufacturers, discussed Zinc in Galvanizing, and showed what the steel producers are doing in trying to extend the uses of galvanized sheet.

If a substitute for galvanizing were found that would displace it from consumption, it would not continue to be used. Competition comes from other materials and other industries, in cement and prepared roofing for example. Unless galvanizers continually improve their product, and let people know its virtues, it will be a struggle to hold the present market, to say nothing of extending it. Group action by the steel manufacturers, so far without much help from the zinc producers, is helping to hold and extend the market. He pleaded for technical and market research, backed by the zinc industry as a group.

W. A. Willis, Manager, Copper and Brass Research Association, dealt with Zinc in Brass, and discussed the value of technical and market research and of group action as shown by the experience of his association.

R. M. Roosevelt, President of the American Zinc Institute, as presiding officer, continually stressed the value of research. Modern finance, he said, is a bull on industries that base their business on research, and a bear on those that do not. In fact, the session might as well have been called one dealing with research on zinc as with markets for it, as it was made rather plain that the latter depended on the former.

Whether the Institute as a whole is ready to take the remedy suggested for the present depressed state of the zinc industry, remains to be seen.

Chicago Metal Exposition Floor Plans

Floor plans of the twelfth annual National Metal Exposition which will be held at the Stevens Hotel in Chicago, September 22–26, inclusive, have been mailed to prospective exhibitors, according to W. H. Eisenman, secretary of the American Society for Steel Treating and director of the exposition.

The facilities of the Stevens Hotel will provide a beautiful setting for the 1930 exposition, which is expected to surpass every previous show in convenience and attractiveness. For the first time all activities of the National Metal Congress and Exposition will take place under one roof. Technical sessions, the annual meeting of the Society, and other features of the Congress will all be held in the Stevens Hotel.

The 1930 show will cover approximately 75,000 square feet of floor space. On the first floor of the hotel, in the great exhibition hall and foyer, will be set up the heavy displays. Second floor exhibits will be located in the grand ball room and its foyer, and in the lounge, writing room and main dining room of the hotel. No restrictions are imposed by the exposition management as to the showing of heavy machinery, whether or not in operation.

A unique feature of the exposition is its all-expense cost to exhibitors, a new departure in show management. The exhibitor's booth rental includes cost of cartage to and from the railroad terminals; erection and dismantling of exhibits; the installation of connections for gas, electricity, air and water as well as the cost of the current, gas, etc., used; furniture, carpenter work, signs and other charges hitherto paid separately by the exhibitor. Rental costs per square foot vary with the requirements of the individual exhibitor.

Correction to Translation in April 1930 issue. On page 480, right column, last paragraph, the word "arc" should read "spark." Page 482, right column, second paragraph, the word "arc" should read "spark."

Corrosion and Heat-Resisting Steels

As Applied to Automobile and Bus Use*

By C. M. Johnson[1]

Numerous articles have been published on this general subject, among which are those by T. Holland Nelson,[2] J. A. Mathews,[3] J. H. Monypenny,[4] and O. K. Parminter[5] and the author.[6] The latter was the outcome of investigations which the author began in 1917 to find, if possible, a heat-resisting metal for electrical heating wire not covered by the Marsh patents.

In writing of the present and future of heat and corrosion-resisting steels, a glance at the past should not be omitted. This is best accomplished by a brief survey of patent literature:

Brearley's Stainless Steel and Iron (the first to be filed in the United States).—"An Improvement in Cutlery," No. 1,197,256, by Harry Brearley of Sheffield, England. Filed a second time in United States Patent Office on March 6, 1916 (also filed March 29, 1915), and granted September 5, 1916. This patent covered a hardened and polished steel containing 9–16% of chromium and a carbon content not greater than 0.7%. The disclosure stated that a steel containing less than 8% of chromium is relatively tarnishable. A typical analysis was given as 0.30 % carbon, 0.30 % manganese and 13.0 % chromium. This was the beginning of "stainless iron and steel."

Haynes' Patent.—An improvement in wrought metal articles. U. S. Patent No. 1,299,404 by Mr. Elwood Haynes of Kokomo, Ind., filed March 12, 1915, and patented April 1, 1919. The late Mr. Haynes' claims were filed, therefore, in the United States within a few days of Mr. Brearley's first filing. Mr. Haynes' discovery included steel with from 8 % to not more than 50–60% of chromium. The best carbon range was given as from 0.10–0.50%. Of course, the Haynes' claims took in Brearley's and more. The patent office evidently studied over this fact for four years and became weary of answering letters from the patent attorneys and decided that, since Haynes had a broader claim, somewhere between 8 and 60% of chromium were steels that Brearley had not covered. Both of these patents were purchased by the American Stainless Steel Co. of Pittsburgh, Pa.

Armstrong U. S. Patent No. 1,322,511.—An improvement in stable surface alloy steel filed May 24, 1919, patented November 25, 1919, by P. A. E. Armstrong, "a subject of Great Britain," residing at Loudonville, N. Y. This patent contains seven claims, Claim No. 1, which might be termed the overture, reads as follows: "An alloy of high surface stability containing 3–50% chromium, carbon 0.05–3.5% but not more than one-tenth of the chromium, and silicon taken together up to about 13% thereof and not more than one-sixth thereof above about 13%, silicon under 8%, over 6.5% and also over twice the carbon, silicon and chromium together 5–58% and the principal portion of the remainder iron."

As the result of an infringement suit, the U. S. Court of Appeals held that so far as cutlery was concerned, the Armstrong patent infringed the Haynes and Brearley patents. But a recent suit reversed the decision so far as valve steel is concerned and held that the Armstrong claims within certain limits are valid and infringed.

Johnson Patents Nos. 1,420,707, 1,420,708 and 1,612,334.—An Improvement in Alloy Steels by C. M. Johnson of Avalon, Pa. Claims were filed August 6, 1920, including steels from 9–20% chromium, 1–10% silicon and about 9–25% nickel. Two supplementary patents were granted extending the limits from 6–25% chromium and the nickel to 36%. The first patent was granted June 27, 1922. The addition of notable amounts of silicon to chromium and nickel give properties to be mentioned later.

Benno Strauss Patents Nos. 1,404,907, 1,404,908, 1,533,712 and 1,587,614.—The Strauss claims covered straight chromium-nickel-iron alloys. Patent No. 1,404,907 covered the chrome-nickels up to 25% chromium and 20% nickel, and No. 1,404,809 patented the heating of such steels to as high as 2192° F. to secure greatest ductility. This heat treatment was described by the author in his paper presented before the American Society for Steel Treating.[6]

The entire patent situation has been recently clarified by the purchase of the Armstrong, Strauss and Johnson patents by the Krupp-Nirosta holding company.

Practical Developments in Stainless Iron and Steel

To the automobile builder the most interesting applications of straight chromium steel is that of valve steels, but these have largely, so far as the author knows, given way to silchrome valve steel of the Armstrong patent. The stainless iron which is of the same analysis as stainless cutlery with the carbon dropped to 0.10–1.14%, has found a use in nuts and bolts and the like. A typical analysis of stainless iron is 0.12 % maximum carbon, 12–14% chromium and 0.50% maximum silicon. It can, by normalizing, then annealing to a Brinell hardness of about 143, oil quenching from 1750° F. and drawing from about 1100° F. in 0.505-in. section, be made to show a tensile strength of 165,000 lb./in.^{2}, a yield point of 134,000 lbs./in.^{2}, an elongation of 13–17%, and a reduction of area of 64% (composition: 0.10% carbon, 0.37 % manganese, 0.12% silicon and 14% chromium). According to Monypenny, the manufacture of stainless iron began in England in June 1920. He gives its tensile strength as 35–70 tons/in.^{2} and describes it as a valuable steel for pump rods and valves.

Silicon-Chromium Valve Steel

The creation of Armstrong occupies a prominent position as successful application to heat-resisting valve steels of the analysis already given of about 0.40 % carbon, 9% chromium and 3% silicon.

Next in order we can consider the straight chromium-nickel steels of Strauss. These are widely used at present.

This now very stylish straight nickel-chromium iron alloy is nickel plate all the way through and likewise chromium plate all the way through. This modish metal is known by various names, such as Central's KA-2, Ludlum's KA-2, Allegheny, or Rezistal KA-2, and Krupp-Nirosta's KA-2.

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* An extented abstract of a paper presented as a part of a Symposium on Developments in Automotive Materials at the Detroit Regional Meeting, American Society for Testing Materials, held at Detroit, Mich., March 19, 1930. Published by permission of the Executive Department of Crucible Steel Co. of America.

[1] Chief Chemist, Park Plant, Crucible Steel Co., Pittsburgh, Pa.

[2] T. H. Nelson, *Iron Age*, Vol. 123, April 25, 1929, pages 1139–1142; May 30, 1929, pages 1478–1482; Vol. 124, October 3, 1929, pages 887–890.

[3] J. A. Mathews, "Recent Developments in Corrosion Resistant and Heat Resistant Steels," *Industrial and Engineering Chemistry*, December 1929.

[4] J. H. Monypenny, "Stainless Iron and Steel," 1926.

[5] O. K. Parminter, "High Chromium Steels," *Transactions American Society Steel Treating*, Vol. 15, May 1929, pages 796–816.

[6] C. M. Johnson, "Properties and Microstructure of Heat-Treated, Non-Magnetic, Flame, Acid and Rust-Resisting Steel," *Transactions American Society Steel Treating*, Vol. 1, July 1921, pages 554–575.

As much has been written on the heat treatment properties of the straight chrome-nickel steels, the author will mainly mention the typical chemical analyses and some physical properties. It is convenient to quote the figures given by T. Holland Nelson[7] for this class of steel, as follows:

Carbon	0.07–0.15%
Silicon, maximum	0.75%
Manganese, maximum	0.50%
Nickel	8–10 %
Chromium	16.5–19.5 %

The following physical properties can be obtained by heating to temperatures ranging from 1850–2100° F. and cooling in air:

Tensile strength, lbs./in.^{2}	85,000–95,000
Yield point, lbs./in.^{2}	30,000–40,000
Elongation in 2 in., percent	55–60
Reduction of area, percent	70–75
Izod impact, ft.-lb	100–120
Brinell hardness	130–140

Monypenny favors a composition of 15–16% chromium with 10–11% nickel, 0.10% carbon, 0.25% silicon and 0.25% manganese, as a better all around type of austenitic steel. There is no doubt that this is a more ductile composition than KA-2. He gives in round figures for such a steel: yield point 19 tons/in.^{2}, ultimate stress 39 tons/in.^{2}, reduction of area 72.6%, elongation in 2 in. 70%, Izod impact 105–109 ft.-lb. By comparison he gives a similar composition except with silicon in the Johnson range: 0.10 % carbon, 1.34% silicon 0.22% manganese, 15% chromium, and 9% nickel with the higher physical values: ultimate stress 58.9 tons, elongation in 2 in. 57%, reduction of area 51%, Brinell hardness 163, Izod impact 115–120 ft.-lb.

Chromium-Silicon-Nickel Steels

This brings us to the chromium-silicon-nickel steels which are preeminently the heat-resisting steels. The straight 24–26% chromium iron is also of high heat resistance. See patent of F. M. Becket, U. S. Patent No. 1,245,552, November 1917. The chromium-silicon-nickel steels are coming into use for heat resisting valves and valve insert seats. As regards the valves, that part which requires more hardness and is not subjected to the erosion and heating can be made of ordinary 3140 S. A. E. Steel for example, which is welded on to the Rezistal portion of valve, which operates in the heated and corroding location.

As to loss due to oxidation at high temperature, one can refer to the author's paper read at A. S. S. T. Convention in August 1920 in Philadelphia[6] and to a quite recent paper by Mathews.[3]

Chromium-Silicon-Nickel Valve Steels

Heat-resisting valve steels, 0.40% carbon, 12% chromium, 2.5% silicon and 7.5% nickel have proved valuable in airplane engines (Mathews) and 0.40% carbon, 14% chromium, 1.5% silicon, 13% nickel and 2.2% tungsten, has been used considerably in Europe (Mathews) for heat-resisting valve steels.

Ductility and Weldability of Chromium-Silicon-Nickel Steel

Welding.—These steels can be welded by electric or gas welding. The welds in each case possess high ductility but care must be taken not to carburize the welds by using a mixture too high in acetylene or any other carburizing gas. It is an easy matter to carburize a weld from a carbon content of 0.25% to as high as 1%, by using too little oxygen in the combustion mixture—atomic hydrogen welding is good for this work. These high chromium-silicon-nickel alloys can be welded by the electric method to gray cast iron securing a weld that is stronger than the cast iron itself.

Ductility.—The ductility of the chromium-silicon-nickel steels is extremely high in the lower carbon compositions. The author can cite a recent case in which a sheet $^1/_8$ in. thick of 0.08% carbon, 20.4% chromium, 2.06% silicon and 8.84% nickel was bent flat on itself cold. As a further example of ductility, this grade can be rolled in sheets of razor blade thickness and wire 0.005 in. in diameter and less.

Physical Properties.—The 0.08% carbon, high silicon grade, $^1/_8$ in. thick, showed the following properties:

Tensile strength, lbs./in.^{2}	99,000
Yield point, lbs./in.^{2}	47,000
Elongation in 2 in., percent	69
Reduction of area, percent	71

Table I—Results of Pittsburgh Corrosion Tests of Corrosion-Resisting Steels

No., Description and Grade	Date Weighed	Weight g.	Change in Weight, g.	Chemical analysis, % of C	Cr	Ni	Si
472, cold rolled, 0.013 in. thick, 0.013 in., Jan. 23, 1930 (Grade No. 2)	11/25/22 1/25/26 1/23/30	132.5 132.5 132.8	0.3 gain	....	14.6	10	2 – 3
482–8, heated to 2150° F. before exposure, hot rolled, 11$^1/_4$ × 4$^1/_8$ × $^3/_{32}$ in. (Grade No. 3)	10/22/23 4/24/24 1/23/30	402.2 402.0 402.6	0.4 gain	0.35	16	15	2.90
482–8, hot rolled, no treatment, 11$^3/_4$ × 4 × $^1/_{16}$ in. (Grade No.3)	9/ 9/21 11/21/22 1/26/26 1/23/30	331.0 331.0 332.5 332.0	1.0 gain	....	...	..	....
472–6, hot rolled, 11$^1/_4$ × 3$^7/_8$ in. (Grade No. 2)	9/ 1/21 11/25/22 1/26/26 1/23/30	411.0 412.5 412.6 412.2	1.2 gain	0.29	14.6	10	2 – 3
482, 0.011–0.012 in. thick, cold rolled, 5$^1/_2$ × 12 in. (Grade No.3)	11/25/22 1/25/26 1/23/30	83.0 83.5 85.0	2.0 gain	....	....	..	....
(Gaged 0.011 in. on Jan. 23, 1930, after scraping off dirt down to bright metal)							
Stainless iron, cold rolled, 14$^1/_4$ × 4$^1/_8$ in.	10/31/23 4/24/24 1/23/30	184.65 184.7 186.0	1.35 gain	Analysis not recorded.			
484–1, hot rolled, 16 gage, no chromium present	10/15/20 11/25/22 11/22/23 1/23/30	417.24 417.0 413.5 409.8	7.44 loss	....	None	25	3.70
485–2, hot rolled, 11$^1/_4$ × 3 $^7/_8$ in. (Grade No. 4)	10/ 1/21 11/25/22 4/24/23 1/25/26 11/23/30	354.1 355.0 355.0 355.0 355.7	1.6 gain	0.34	16.95	25	4
514–12, 15$^1/_8$ × 2 in. (Grade No. 5)	11/28/22 1/26/26 1/23/30	265.5 265.0 265.3	0.2 loss	....	Approx. 12	34	

In the case of these highly resistant chrome-nickels if left to themselves the insidious ferric sulphate will form in the dirt and acting slowly over a long period will produce rusting enough to be noticeable.

Rust Resisting Steel with Plain Steel Inserts

The scheme of using rust resisting steel with plain steel inserts offers possibilities where heavier sections such a bumpers are desired with a considerable outside surface layer of the resistant steel and ordinary spring steel inside. For example, a $^1/_4$-in. section can have close to a $^3/_{64}$-in. all around outside layer of the higher priced alloy steel.

Further Data on Stainless Iron

Machinability.—Stainless iron can be machined well when heat treated and tempered to a Brinell hardness of 250–300.

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[7] T. H. Nelson, "Chromium-Nickel Stainless Alloys," *Iron Age*, Vol. 124, October 3, 1929, pages 887–890.

Forging.—The steel should be slowly heated to 1700–2050° F. for forging. Holding too long at high temperatures promotes grain growth. It should not be forged below 1600° F.

Annealing.—For annealing, the steel should be heated to 1450° F. and held for a length of time depending on the size, then cooled slowly. Actual annealing takes place at about 1350° F. but any steel should be heated beyond its carbon change point, that is a little above the lowest heat at which it will harden if quenched. Then the temperature should be lowered to the true annealing temperature.

Hardening.—For hardening, the steel should be heated to about 1750–1850° F. (preheating slowly to 1350° F.), then quenched in oil and drawn to the desired hardness.

Surface Permanence.—Highest stain resistance is secured by removing absolutely all scale and polishing the surface. Heat treatment even in the low-carbon grade helps in securing best surface stability.

Heat Treatment of Stainless Iron.—The chemical analysis was as follows:

Carbon	0.10 %
Manganese	0.27 %
Silicon	0.10 %
Phosphorus	0.013%
Sulphur	0.018%
Chromium	12.23 %
Nickel	0.53 %

A specimen $1^1/_2$ in. round, fully annealed, was treated in full size section. Specimen No. 1 was quenched in oil from 1750° F., drawn at 1170° F. for 45 minutes and had a Brinell hardness of 228. Specimen No. 2 was quenched in oil from 1750° F., drawn at 1100° F. for 45 minutes and had a Brinell hardness of 255.

Samples were quenched in oil at 1750° F. and drawn at 640° F. for one hour and gave a Brinell hardness of from 228–241.

Samples were treated from the annealed condition as follows:

Brinell hardness 143
Brinell hardness 163
Brinell hardness 143

Samples of straight Chromium "Stainless" Steels, 1 in. round, of 18, 27 and 12% Chromium showed the following physical properties:

	Chemical Analysis % of				Physical Properties				
	Carbon %	Manganese %	Silicon %	Chromium, %	Brinell Hardness	Yield Point lbs./in.²	Tensile Strength lbs./in.²	Elongation in 2 in. %	Reduction of area %
18 %	0.17	0.42	0.43	17.7	163	47,000	78,500	35	64
24 %	0.23	0.41	0.47	27.15	179	54,200	72,800	37.5	49
12 %	0.10	0.37	0.23	12.59	170	69,700	94,000	20	53.8

Stainless iron of 0.10% carbon, 14.37% chromium, normalized, oil quenched and drawn, showed physical properties as follows:

	Yield Point lbs./in.²	Tensile Strength lbs./in.²	Elongation in 2 in. %	Reduction of Area, %	Brinell Hardness
Hot rolled	77,650	164,200	11	28.2	321
Normalized at 1600° F.	51,100	81,950	26	73.4	192
Annealed at 1380° F.	42,900	73,300	35	73.6	153
Oil hardened at 1750° F.	157,200	173,000	12	33.7	340
Oil hardened and drawn at 700° F.	131,400	105,100	17	50.9	321
Oil hardened and drawn at 1000° F.	131,900	144,650	19	65.3	293

Coefficient of Expansion of Stainless Steel.—U. S. Bureau of Standards Scientific Paper No. 426 gave values for coefficient of expansion of a steel of analysis: 0.30% carbon, 0.11% silicon, 0.18% manganese and 13.1% chromium.

Temperature Range	Average Coefficient of Expansion Hardened	Tempered
20–100° C.	0.0000099	0.0000103
20–200° C.	0.0000098	0.0000107
200–400° C.	0.0000099	0.0000122
400–600° C.	0.0000138	0.0000133
600–800° C.	0.0000134	0.0000136
20–600° C.	0.0000112	0.0000121

Comparison of Impact Values of Straight Chromium and Chromium-Nickel and Chromium-Silicon-Nickel Steels.

Charpy test specimens 0.394 in. square, V notch 0.079 in. deep, area 0.124 in.²

Table II—Physical Properties of Cold-Rolled Rezistal KA-2.[a]

Sample	Brinell Hardness 750-kg. Load 5-mm. Ball	Rockwell Hardness	Yield Point lbs./in.²	Tensile Strength lbs./in.²	Elongation in 2 in. %	Elongation in Gage Length 4.5 × Square Root of Area %	Longitudinal Bend	
A-1	155	85 "B" Scale	53,000	104,000	46.9	57.1	180 deg.	Fully softened 0 082 in thick.
A-2	155	85 "B" Scale	55,000	105,000	43.8	67.0	.....	
B-1	255	29 — 30 "C" Scale	118,000	128,000	21.9	37.5	180 deg.	First cold reduction down to 0.070 in. thick.
B-2	255	29 — 30 "C" Scale	119,000	126,000	20.3	35.0	.....	
C-1	340	37 — 38 "C" Scale	165,000	170,000	7.0	17.5	180 deg.	Second cold reduction down to 0.050 in. thick.
C-2	340	37 — 38 "C" Scale	170,000	173,000	6.3	17.5	.....	
D-1	363	40 — 41 "C" Scale	199,500	200,000	3.1	12.5	180 deg.	Third cold reduction down to 0.035 in. thick.
D-2	363	40 — 41 "C" Scale	194,500	199,000	3.1	9.4	.....	

[a] Analysis of this steel is 0.15 % carbon, 18.83 % chromium, and 10.33 % nickel.

	Yield Point lbs./in.²	Ultimate Strength lbs./in.²	Elongation in 2 in. %	Reduction of Area %
Stainless Iron Sample No. 1	85,000	114,000	22	68.4
Stainless Iron Sample No. 2	95,000	126,250	20	65.2

	Chemical Analysis % of							Physical Properties				
Heat	Carbon	Manganese	Silicon	Phosphorus	Sulphur	Chromium	Nickel	Elastic Limit lbs./in.²	Tensile Strength lbs./in.²	Elongation in 2 in. %	Reduction of Area %	Impact ft.-lb.*
6689	0.08	0.25	0.03	0.010	0.012	12	0.57	Over 60,000	104,200	22	73.7	75
6668	0.11	0.37	0.13	0.019	0.007	13.72	0.76	Over 60,000	116,000	22.5	69	75
6709	0.10	0.33	0.12	...	0.015	14.37	0.48	Over 73,000	103,400	25	70.1	75

* Specimen did not break in two, but bent over at notch. The impact test specimens were 10 mm. square, notched in the middle: depth of notch 0.078 in. width notch 0.062 in., angle of notch 90 deg., radius at bottom of notch 0.01 in.

	Air Cooled from ° F. 1600 *a*	1600 *b*	1800 *a*	1800 *b*	2000 *a*	2000 *b*	2200 a	2200 *b*
CHROMIUM STEEL:								
0.10% C, 12.8% Cr	74	3.8	..	...	..	...	..	...
0.11% C, 18.9% Cr	140	2.3	95	2.3	22	2.3	..	...
CHROMIUM-NICKEL STEEL:								
0.11% C, 0.57% Si, 9.01% Ni, 17.30% Cr	140	109.8	..	...	7	123.5	..	...
0.10% C, 0.40% Si, 25.57% Cr	140	1.8	95	1.4	56	1.4	54	1.4
CHROMIUM-SILICON-NICKEL STEEL:								
0.19% C, 9.24% Ni, 2.14% Si, 18.86% Cr	140	70.8	95	70.8	56	97.9	..	...
0.24% Cr, 3.08% Si, 25% Ni, 17.5% Cr	140	57.9	95	50.8	56	57.9	2	71.8
0.22% C, 1.54% Si, 21.2% Ni, 26.33% Cr	140	6.0	95	40.7	56	52.6	54	54.3

a Time in hours the sample was held before cooling in air.
b Impact ft. 16.

Further Data on Straight Chromium-Nickel Steels —Low Silicon

Forging.—May be forged from 1700–2250° F. For partial softening should be heated to from 1650–1750° F. and cooled in air. For complete softening should be heated to from 2000–2200° F. and cooled in air. Holding this grade too long at 1300° F. lowers the ductility, the so-called brittle range of heating.

Torsion Value.—The yield point in torsion is 21,280 lbs./in.², the shear stress is 100,800 lbs./in.², the degree of twist is 450 deg., and the size of specimen is 5/8 in. round.

Fatigue Strength.—Parminter gives Thomas Firth & Sons, Ltd., as authority for a value of between 38,000 and 39,000 lbs./in.² obtained with a Wöhler rotary bend test.

Effect of Cold Work.—Chromium-nickel steels, as well as the chromium-silicon-nickel steels, can only be hardened by cold working. Table II shows some results obtained on a steel of KA-2 type. (Mathews).

Riveting.—The riveting properties of KA-2 are excellent. Cold riveting is used for smaller sizes and hot riveting, at about 1800–1950° F., for larger diameters.

Welding.—The steels can be welded by electrical or acetylene methods, but care should be taken to avoid carburizing of welds.

Thermal Conductivity.—The thermal conductivity is from about one-half to one-third that of steel.

Permeability.—Permeability is 1.02, but such steels will increase in magnetic susceptibility if held too long at about 1300° F. The author pointed out in his 1920 paper that a 17% chromium, 9% nickel, 2–3% silicon steel is more susceptible if held at about 1300° F. for several hours. It becomes so magnetic that it can be picked up by a magnet. By reheating to 1600° F. and holding for a few minutes at this temperature, the full non-magnetic condition was restored. The 25% nickel, 17% chromium, 2–3% silicon grade is the most permanently non-magnetic under all conditions even after immersion in liquid air for 10–15 minutes.

Coefficient of Lineal Expansion.—The coefficient of lineal expansion of the 18% chromium, low-silicon 8% nickel, type is as follows (Monypenny):

Temperature Range, ° C.	Mean Coefficient of Expansion per ° C.
20–100	0.0000170
20–200	0.0000177
20–300	0.0000181
20–400	0.0000186
20–500	0.0000192
20–600	0.0000201

Parminter gives practically identical figures except for the range 20–600° C., which he records as 0.0000195.

	Radiation %	Reflectivity, as Oven Linings %
KA-2	17	83
Porcelain enamel	90	10
Polished cast iron	25	75
Polished wrought iron	23	77
Polished zinc	19	81

Soldering of KA-2 and Chromium-Silicon-Nickel Grade.—The clean scale-free steel should be brushed over with commercial concentrated hydrochloric acid to roughen the surface so that the solder will stick. The excess acid should be removed and the soldering salt applied. (Yagers Salt or Reducto are satisfactory salts.) A heavy soldering iron should be used. After completing the work, all traces of acid should be removed by washing with soapy water containing sodium bicarbonate solution, as any acid remaining will remove the polish and cause rusting.

Further Data for Chromium-Silicon-Nickel Steels

Since 1920–1921 there have been five major grades.

Grade	Carbon, %	Manganese, %	Silicon, %	Chromium, %	Nickel, %
No. 2	0.10–0.25	0.50–0.70	2.00–3.50	17.00–19.00	8.00–10.00
No. 3	0.10–0.25	0.50–0.70	2.00–3.50	15.00–16.00	15.00–16.00
No. 4	0.10–0.25	0.50–0.70	2.00–3.50	17.00–19.00	25.00–26.00
No. 5	0.10–0.25	0.50–0.70	2.00–3.50	11.00–12.00	34.00–36.00
No. 7	0.15–0.25	0.50–0.70	2.00–3.50	24.00–26.00	20.00–22.00

The tensile values are generally higher than KA-2 types, other elements than silicon being equal. Some further tension test values are given for these steels which are the best all around for heat resistance and welding. Grade No. 5 is the softest of this group. Its chemical analysis is as follows:

Carbon	0.12%
Manganese	0.55%
Chromium	13.20%
Nickel	36.55%

It is easy to machine and its physical properties are as follows:

Tensile strength, lbs./in.²	87,800
Yield point, lbs./in.²	27,000
Elongation in 2 in., percent	35
Reduction of area, percent	33
Brinell hardness	158

All grades afford higher tensile strength and yield point when the carbon content is increased; see Table III.

Table III—Tensile Values of Softened Chromium-Silicon-Nickel Steels 1-in. Round Bars 0.505 in. Section

		Brinell Hardness	Yield Point, lbs./in.²	Tensile Strength lbs./in.²	Elongation in 2 in., %	Reduction of area %
Grade No. 2	0.19% carbon, 0.61% manganese, 2.25% silicon, 19.10% chromium and 10.07% nickel	159	43,000	99,000	66.8	74.3
Grade No. 7	0.24% carbon, 0.64% manganese, 2.50% silicon, 25.75% chromium and 20.75% nickel	179	57,000	109,000	42.5	44.9
Grade No. 4	In castings		47,400	84,000	19.5	16.6
	Forging as rolled		69,650	116,900	32.0	50.2
Grade No. 4	Forged and softened from 2150° F. 0.20 – 0.30% carbon, 0.60–0.70% manganese, 25.00–26.00% nickel, 17.00–18.50% chromium and 2.00–3.00 silicon		48,330	99,440	48	48
	0.20–0.30% carbon. Air cooled from 2150° F.		47,200	107,700	43	59

Tensile Properties at Elevated Temperatures.—At elevated temperature in the vicinity of 1000° F. the tensile properties are influenced by the amount of cold work the steel has undergone, also by the degree of annealing. For example take grade No. 4, soft annealed, at 550° C. (1022° F.) the tensile strength is 65,000 lbs./in.² with a reduction of area of 42% and an elongation in 2 in. of 32%; whereas the same grade hot rolled unannealed can be produced to show a tensile strength of 90,000 lbs./in.² This soft grade shows also the following values:

	Tensile Strength lbs./in.²	Elongation in 2 in., %	Reduction of Area, %
650° C. (1202° F.)	45,000	36	53
750° C. (1382° F.)	40,000	38	54
850° C. (1562° F.)	11,000	46	58

Hot rolled, unannealed grades give the following values.

550° C. (1022° F.)	95,000	24	23
700° C. (1292° F.)	71,470	24.7	20
800° C. (1472° F.)	45,000	62.8	28.5
960° C. (1760° F.)	18,000	70.1	48.5

Grade No. 2, high carbon showed the following values:

960° C. (1760° F.)	23,180	29.5	45.7

Grade No. 4 showed the following values:

960° C. (1760° F.)	22,400	36	53.8

(All of the above are short-time tests.)

Tensile Properties after Different Treatments

Grade No. 2 chrome-silicon-nickel steel 1 in. round of 0.25% carbon, 0.62% manganese, 2.14% silicon, 9.11% nickel, 19.49% chromium showed the following values:

	Condition	Brinell Hardness of Specimen Bar	Yield Point lbs./in.²	Tensile Strength lbs./in.²	Elongation in 2 in., %	Reduction of Area %	Brinell Hardness
R	As rolled	277	94,000	130,000	35.5	50.9	277
R-16	1600° F., Cooled in Air	269	80,000	127,000	37.1	52.5	269
R-18	1800° F., Cooled in Air	228	57,000	119,000	46.7	62.1	223
R-20	2000° F., Cooled in Air	217	51,000	108,000	56.6	69.1	197
R-22	2200° F., Cooled in Air	174	43,000	99,000	66.8	74.3	159

	Brinell Hardness	Charpy Impact, ft.-lbs.	Charpy Impact, ft.-lbs./in.²	Scaling
R	277	44.0	354.3	None
R-16	269	64.3	518.0	None
R-18	228	83.3	672.0	None
R-20	217	125.4	1012.0	None
R-22	174	180.9	1458.0	None
R-24	156	216.2	1745.0	Scaled very badly

The pieces were held one hour at temperature and cooled in air. Charpy test R-24 stopped the pendulum on the impact machine. The test specimen did not break. (Atha data.)

Tensile Properties of High-Carbon Chromium-Silicon-Nickel Steel Grade No. 2 Compared with Those of High-Carbon Low-Silicon Chromium-Nickel Steel, 1 in. Round Bars

CHEMICAL ANALYSIS

	Carbon, %	Manganese, %	Chromium, %	Nickel, %	Silicon %
Grade No. 2, chromium-silicon-nickel steel..........................	0.43	0.81	18.44	9.70	2.82
Grade No. 320, chromium-nickel steel	0.56	0.15	18.39	9.53	0.29

PHYSICAL PROPERTIES

		Yield Point, lbs./in.²	Tensile Strength, lbs./in.²	Elongation in 2 in., %	Reduction of Area, %
Grade No. 2	Natural	71,500	126,000	37.0	38.8
	Normalized 1650° F.	69,250	125,750	53.5	36.2
	Quenched 2000° F. in oil	70,500	124,500	40.8	48.4
Grade No. 320	Natural	58,750	126,500	30.0	38.7
	Normalized 1650° F.	59,500	128,000	27.5	35.7
	Quenched 2000° F. in oil	62,250	120,500	44.0	43.8

Chrome-Silicon-Nickel Steel Softening Temperature.—By heating to temperatures given until thoroughly heated through and then cooled at once in air. Sheets require only a few minutes. Large sections are heated one hour per inch.

	Temperature ° F	Rockwell Hardness "B" Scale
Grade No. 2................	2050	75—80
Grade No. 4................	2100	80—85
Grade No. 7................	2150	85—90

The lower the carbon, the greater the softness obtained by the above treatment, and, of course, the lower the tensile values.

Forging Temperatures.—Do not forge below 1700° F. Good forging range is 1750–2000° F., never in white heats.

Average Coefficients of Thermal Expansion.—

	Coefficient of Expansion per ° C. Temperature Range, 20–300° F.	Temperature Range, 300–600° F.	Temperature Range, 600–900° F.	Specific Gravity
No. 3, 15% chromium, 15% nickel, 2–3% silicon and 0.030% carbon	0.0000163	0.0000180	0.0000200	7.782
No. 4, 17% chromium, 25% nickel and 2–3% silicon	0.0000159	0.0000179	0.0000204	7.763

The values given for specific gravity are 10–12% less than that of copper-nickel and cupro-nickel metals, an advantage in moving parts.

Welding.—These steels are preeminently the best adapted to electric and acetylene and atomic hydrogen welding processes, the welds being tough and strong, if not carburized.

Resistivity.—These steels have a resistance of 500–600 ohms per mil-ft., and a temperature coefficient of 0.000522/° C. for a temperature range of 0–538° C., and 0.000243/° C. for a temperature range of 538–982° C. Suitable for resistance coils and grids up to 800° C.

Tensile Values at Elevated Temperatures of Chromium-Nickel-Tungsten Steels

W. H. Hatfield[8] gives tensile values of steel of 0.42% carbon, 0.31% manganese, 0.69% silicon, 13.30% chromium, 8.87% nickel, 3.42% tungsten at 950° C. as 50,960 lbs./in.² with an elongation in 2 in. of 16% and a reduction of area of 32.8%. He states that these steels are coming into increasing use. The best strength for ordinary steels at this temperature ranges from about 5000–9000 lbs./in.²

Further Data on Stainless Steel, Stainless Iron and KA-2 (Mathews)

The stainless steel type, 0.30% carbon and 12.5% chromium, has found limited use in needle valves of carburetors also pump shafts and, in general, for any parts where greater hardness or strength may be desired than can be obtained from stainless iron. Its use is limited to parts that must be hardened and tempered. Stainless iron type below 0.12% carbon and 12.5% chromium has been used successfully for pump shafts, bolts and screws and other parts where a strength comparable with that of the ordinary S.A.E. steels may be desired, combined with very good resistance to atmospheric corrosion. Some observations in regard to the heat treatment of stainless iron may be offered with advantage. Stainless iron in any moderate section, up to, say, $^1/_2$–$^3/_4$-in. thick, may be satisfactorily heat treated by free cooling in air from a temperature of 1750–1800° F. Afterwards it should be tempered to give the physical properties desired. There are certain points to be observed in the tempering operation of this steel which are occasionally overlooked. The impact resistance of stainless iron improves gradually with tempering temperatures up to about 800° F. Tempering from about 1100–1250° F. gives very excellent physical properties including high impact resistance and the product is machinable when so tempered. Tempering above 1100° F. should be followed by quick cooling of the tempered parts. Stainless iron type, carbon below 0.10% and chromium 18.0%, is an unhardenable alloy and its physical properties may not be increased by quenching. In general, its resistance to atmospheric corrosion is satisfactory without any heat treatment, when the parts are highly finished. It is generally true of all these products, that the more highly they are finished the more resistant they are to corrosion. Stainless iron with 18.0% chromium should not be used for parts subject to impact as it is rather low in this property. Its principal application is light sheets for moderate forming or drawing operations. It has been successfully used for various parts of automobile trim where forming operations are not too severe.

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[8] W. H. Hatfield, "Application of Science to the Steel Industry," *American Society Steel Treating*, 1928.

Chromium-nickel steel, 18.0% chromium, 8.0% nickel type, carbon below 0.15%, is an austenitic, unhardenable, non-magnetic alloy. It takes a beautiful polish and color which is permanent. When heat treated or softened it shows a very high Erichsen figure of from 13–15.

Ferro-nickels.—A ferro-nickel of the Invar type has found large application in struts used in aluminum pistons and a further use of material of this type is in conjunction with various thermostatic devices such as automatic radiator shutters in which a ferro-nickel of very low expansion is employed in conjunction with a metal of high expansion to constitute a thermostatic element. The chromium-nickel steels of the type described above and practically all of the austenitic types which have been developed show a coefficient of expansion about 50% greater than that of iron but the particlar type that has been employed in connection with the ferronickel of Invar type is approximately 22% nickel and 9% chromium.

Valve Steel Types (Mathews)

The evolution of gas engines with increased pressures, temperatures, speed of operation and synthetic fuels has brought about increased demands for superior valve material. Characteristics desired in a good valve are (1) resistance to scaling at operating temperatures (2) fair hardness and strength at operating temperatures and (3) critical temperature above the operating temperature so that the valve on cooling will not be subject to hardening through air hardening with accompanying brittleness. The chemical analyses of several types of valve-steel alloys that have been or are being used are given below:

Type	Carbon, %	Chromium, %	Silicon, %	Nickel, %	Tungsten, %	Molybdenum, %	Cobalt, %
No. 1	0.60	3.5	...	...	14.0	...	...
No. 2	0.30	13.0	0.4	...	...	...	...
No. 3	1.30	12.75	...	...	...	0.75	3.0
No. 4	0.40	9.0	3.0	...	...	...	...
No. 5	0.40	12.0	2.5	7.5	...	...	...
No. 6	0.40	14.0	1.5	13.0	2.2	...	...

Type No. 1 represents the so-called high-speed type of valve which is now obsolete.

Type No. 2 is stainless steel which came into use during the war period owing to the scarcity and high price of tungsten steel but is now also obsolete.

Type No. 3 is PRK cobalt-chromium steel used to a small extent in this country and abroad.

The No. 4 is the well-known sil-chrome very widely used for the past decade.

Type No. 5 is known as CNS valve steel and has met favorable reception in airplane engines.

Type No. 6 is the type of valve steel which has been considerably used abroad but only to a very small extent in this country.

Further Service Data on Heat-Resisting Chromium-Silicon-Nickel Steels and Chromium-Nickel Steels

Certain annealing furnaces are equipped with type No. 4 of the chromium-silicon-nickel steels for two or three years with no indication whatever of failure. Also hardening furnace hearth rolls of KA-2 bars have been in operation for over two years with carburized gears passing over these rollers in electrically heated furnaces. Where furnaces are oil fired, type No. 7 should be used due to the liability to attack from sulphur fumes from sulphur-bearing oils. Type No. 4 has also been used with much success for rollers, chains and belt parts in continuous heat-treating furnace.

Further Data on Chromium-Silicon Nickel Steel Carburizing Boxes

A recent service report on carburizing boxes of chromium-silicon-nickel steel shows 12,000 heat hours and the boxes look as good as new. These boxes are of welded plates 1/6 in. thick. Also the light-weight feature mean less heat energy and time consumed in bringing the lighter welded boxes to temperature. A cast-steel box weighs for example 18,000 lbs., whereas a light-weight chromium-silicon-nickel steel box of about the same capacity weighs 2730 lbs. The cast-steel box of plain steel has a life of from 300–3000 hours, while the light-weight box is sold with a guarantee of 2000 heat hours for the same job.

Effect of Sulphur in Machinability on Chromium-Silicon-Nickel Steels

The effect of adding sulphur in various ways to improve the machining qualities of the different stain and corrosion-resisting grades of chromium-silicon-nickel steel is being studied pretty generally. The conclusions so far are that the resistant properties are not appreciably affected nor the tensile values, whereas the machinability is greatly improved. If no other objections are found, this improved machining quality will widen the field of usefulness and enable the engineer to use higher carbon content steels which have the greater strength and wear resistance in the natural, as rolled, condition. For example, grade No. 2 of 1.25% carbon steel in 1/4-in. round bars in the natural condition, can be coiled at a low red heat into a spring which at room temperature is about equal to a hardened and tempered plain 1.00% carbon steel coiled spring. No heat treatment is required to secure this spring quality in the high-carbon grade No. 2 resistant steel of the cross-section mentioned.

The tabulation below is a concrete case taken from the Atha Plant Report showing the relation of high-sulphur steels to low-sulphur steels.

Salt Spray, 5% Sea Salt Solution.—One-hundred-hour continuous tests showed no difference between the high and low-sulphur steels either in the natural or quenched conditions. Quenching, however, seemed to improve the resistance of both grades.

Standard Test for Resistance to Stain.—Testing in copper sulphate solution revealed no superiority of the low-sulphur steel as compared to the high-sulphur steel.

Microstructure differed only in the presence of sulphide streaks in the high-sulphur steel.

	Chemical Analyses							Physical Properties					
	Carbon %	Manganese %	Phosphorus %	Sulphur %	Silicon %	Chromium %	Nickel %	Condition	Brinell Hardness	Yield Point lbs./in.²	Tensile Strength lbs./in.²	Elongation in 2 in. %	Reduction of Area %
Grade No. 2-C Rezistal 1¼ in. round	0.22	0.73	0.011	0.015	2.70	18.40	10.17	Natural	241	73,000	129,500	38.2	50.3
								Quenched in water from 2050° F.	156	45,000	106,000	62.3	70.1
Grade No. 2-C Special 1⅜ in. round	0.16	0.55	0.010	0.162	2.16	19.13	10.19	Natural	229	76,000	123,000	41.9	57.6
								Quenched in water from 2050° F	163	44,000	104,000	60.2	67.9

The Group of Steels Offering the Highest Resistance to Oxidation Above 2000° F. and Also Having the Highest Tensile Strength and High Resistance to Sulphur Gases in This High Temperature Range

	Carbon %	Manganese %	Chromium %	Nickel %	Silicon %
(A)	0.18–0.30	0.60–0.80	30–32	10–12	1.0–1.50
(B)	0.18–0.30	0.60–0.80	25–27	15–17	1.0–1.50
(C)	0.18–0.30	0.60–0.80	22–24	20–22	2.0–2.50
(D)	0.18–0.30	0.60–0.80	28–30	0–2	1.0–1.50

The lower the nickel and the higher the chromium content the better the resistance to sulphur at high temperatures.

These steels should not be forged below about 1750° F; and then, after forging, should be reheated to the highest forging temperature. In general, for the chrome-nickels to about 2000–2100° F. In the case of (A) for example, it should be reheated until thoroughly heated through; held for at least ten minutes at close to 2200° F; and then cooled in air to secure maximum toughness. If such a steel is forged below the proper temperature it will be easily fractured, transversely, although its grain is highly refined. The best forging temperature for (A) is about 1950–2000°F. After such a steel is softened from 2200° F. and cooled in the air, it can be beaten out cold to a considerable degree.

Further Data on Acid Resisting Steels for Pickling Tanks, Racks, Rods, Etc.

No. 255 (A)—This steel shows a penetration by attack of 10% sulphuric acid at 90° C. in the absence of ferric salts of 0.03″ per year.

A practical test of a welded tank in continuous operation for one year pickling a wide variety of steels has just been completed. The side walls and bottom are in excellent condition. The total loss of weight due to all causes is less than 8% of the original weight of the tank. Penetration in inches per year is 0.03″. The tensile values of this grade are as follows:

	Ultimate Strength in.^{2}	Yield Point in.^{2}	Elongation in 2 in. %	Reduction of Area %	Brinell Hardness
No. 65976	109,900	69,600	45	43	207

Grade B—This grade was developed by the writer for high resistance to sulphuric acid (10%) in the presence of all concentrations of ferric sulphate at 90° C. It has also high resistance to hot 30% nitric acid, being penetrated at the rate of 0.014″ per year. Its penetration by molten caustic soda at 800° F. is 0.055″ per year. This grade has high resistance to scale loss at 1650/1700° F. This steel can be machined, doubled seamed and threaded. Its tensile strength is as follows:

	Ultimate Strength in.^{2}	Yield Point in.^{2}	Elongation in 2″ %	Reduction of Area %	Brinell Hardness
No. 65990	114,800	81,700	27.7	27	228

Both of these steels are in the Rezistal family.

Steel Consumes Great Bulk of Manganese

About 95% of the manganese consumed in the United States is used in the manufacture of steel, the principal base alloys being ferromanganese and spiegeleisen, according to the United States Bureau of Mines, Department of Commerce. There is considerable manganese in many varieties of steel including spring steels, plate steels, structural bar types, rail steels, and various steels used in the manufacture of wheels, tires, axles, armor plate, etc. Formerly manganese steels containing 1–1.5% manganese were classed as good-grade Bessemer steel, but recently they have been classified as alloy steels and have been put on the market under various trade names. Such steels have excellent tensile strength and ductility, with high resistance to abrasion, and are used extensively in caterpillar shoes, truck wheels and other appliances where relatively low cost and high quality are required. A manganese steel containing 12–14% manganese is used in castings for ball mills, pulverizing machinery and rock-crusher jaws because of its resistance to impact wear and of its hardness. Manganese is also an important constituent of nickel and molybdenum steels. Molybdenum steels usually contain 0.2–0.4% molybdenum and 1–1.5% manganese. Nickel-manganese steel usually contains approximately 1% nickel, 1–1.5% manganese and 0.3–0.4% carbon. The nickel adds ductility and toughness but increases the cost.

Increasing Importance of Manganese Warrants Further Study of Its Oxides

Manganese has always been an important adjunct to the production of steel, its chief function being to remove oxygen when added to molten steel. Its additional value as an alloying element has been recognized for nearly a century. In the past few years manganese specifications have increased as its desirable properties as an alloying element have been more apparent in various types of steel.

Although information on the rates of reduction of iron oxides is rather limited, less is known about rates of reduction of manganese oxides. The North Central station of the United States Bureau of Mines, in cooperation with the University of Minnesota, Minneapolis, Minn., is undertaking an investigation of the equilibria between carbon, oxygen and manganese, preparatory to a later study of rates of reduction of manganese oxides, a more difficult problem. Rates of reduction of manganese oxides and silicates will apply to present methods for production of ferromanganese and will also be useful in developing pyrometallurgical methods for utilizing domestic deposits of low-grade manganese material.

Ryan, Scully & Company, manufacturers of industrial furnaces, forges, controllers, etc., announce that plans have just been completed for a new office and manufacturing building at Westmoreland and Stokley Streets, Philadelphia. The new building, with an estimated cost of $100,000, will more than triple the present facilities and will have direct connection with the Pennsylvania Railroad. With these increased facilities for both manufacturing and shipping Ryan, Scully & Company will now assemble equipment and ship direct from the plant, instead of assembling equipment on the job as was done previously. Eugene A. Stopper, Architect, at 10 So. 18th Street, Philadelphia, is in charge of the construction.

Tube-Turns, Incorporated, Louisville, Ky., manufacturers and marketers of seamless, short radius forged fittings for pipe welding announce the appointment of six new distributors.

The new distributors are the Grinnell Company, at Charlotte, N. C., for North and South Carolina and Georgia; Ebbert & Kirkman Company, Inc., of Birmingham, Ala., for Alabama; the B. Hoffmann Manufacturing Company, of Milwaukee, for Milwaukee and adjacent territory; the United Pipe & Supply Company, of Charleston, W. Va., for Charleston and adjacent territory; the Vulcan Copper & Supply Company of Cincinnati for Cincinnati, and adjacent territory, and Hedley & Voisinet of Buffalo, for Buffalo and surrounding territory.

Each of the new distributors carry complete stocks of Tube-Turns.

A new Division of the Steel Founders' Society of America, Inc., was organized at Cleveland, Ohio, on May 14th. This Division, the Alloy Castings Division, is devoted to the producers of heat, acid and corrosion resisting alloy castings. There are now three Divisions within the Society devoted to castings: 1. Small Castings Division (Electric Process). 2. Large Castings (Open Hearth Process). 3. Alloy Castings Division (Heat and Corrosion). The purpose of the new Division is to promote general improvement in the manufacture and sale of Alloy Castings, improve conditions generally and eliminate waste thereby rendering a better service to the ultimate consumer.

A Temperature Controller at McGill University

By Gordon Sproule[1]

> *It is easy for the research worker to see how advantageous it would be to have automatic control of various heating and cooling cycles. It is more difficult to devise a reliable controller. Hence, this description of one that has been tried out over a period of years should be of be of interest to metallurgists.*

At McGill University the students of Metallurgical Engineering, in the second half of their fourth year, spend two days per week on "thesis" work. This comprises preliminary study and extended laboratory work on a definite problem, selected from a list including both fundamentals, such as constitution diagrams of alloy systems, and technical processes, such as the roasting and smelting of a copper ore. These exercises give the men practice in various metallurgical operations—chemical analysis, furnace work, pyrometry, metallography, mechanical testing, etc.,—and demonstrate the utility and coordination of these branches of the subject. The final report or thesis is not the least important part of the work.

A technical process very suitable for thesis work is the annealing of malleable cast iron, and this has been carried out by students twice in recent years. The maintenance of constant temperature in a small laboratory furnace without automatic control equipment presented quite a problem, and on the second occasion the student, Mr. Geo. J. Farnworth, and the writer devised an attachment for a Leeds & Northrup potentiometer recorder to make it control the tool-type Hump furnace in which the annealing was carried out. This attachment has since been elaborated so that it will hold the furnace at any constant temperature between room temperature and 1000° C., or it will cause the furnace to heat or to cool at any of a number of rates, over any range.

So many of these excellent instruments are in use that it is believed many readers may want to apply this attachment.

The maximum rate of cooling is, of course, fixed by the insulation of the furnace, the load in it, and the temperature range included. At present the maximum controlled rate of cooling is 13° C. per hour, which is comparable to the natural or uncontrolled rate at low temperatures with an average load in the furnace. The minimum rate of cooling is $1^1/_2$° C. per hour.

The maximum and minimum controlled rates of heating are respectively three times and one third of the above. Typical records are shown in Fig. 1. The maximum controlled rates of cooling and heating could be extended by procuring additional gears; only standard "Meccano" gears have been used, and up to the present these have sufficed. The equipment, as it is now, has been used a great deal for constant temperature experimental work of all kinds, and or slow cooling of malleable cast iron, steel, permalloy, ceramics, etc. The final results of a malleable anneal performed for an Extension Course night class a year ago are shown in Figs. 2 and 3.

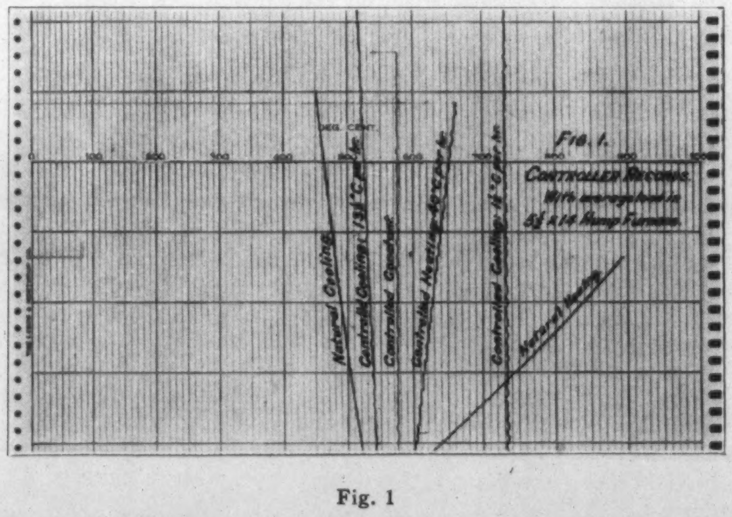

Fig. 1

Briefly described, the automatic controller consists of a relay that cuts in and out a variable block of resistance independent of the regular controlling rheostat. The low and high currents are set a reasonable amount apart, at values dependent on the control temperature, or range to be included. For control at low temperatures, for example, the 220 Volt current alternates between zero and five amperes, and at high temperatures between five and eight amperes, as the relay functions. With this arrangement and with the thermocouple close to the heating element, as it should be, the loaded furnace is held within a degree or so of the control point, as shown by the records. (Fig. 1)

The relay itself comprises a magnet-operated mercury switch and a pair of platinum-tipped contacts closed by the glass-pen of the recorder as it touches the control temperature. The mercury switch is a home-made affair energized by three No. 6 dry cells, in series, which last a long time. The pen is now on the "low" side of the contacts, so that the switch is made to stay closed by gravity, and to open and cut in resistance when the pen rises to the control point and closes the magnet circuit. This simplifies manipulation during heating-up periods, and in recording uncontrolled temperature histories, such as "humps," the controller is always ready to protect the furnace, as it cannot be set higher than 1000° C. After an experiment the furnace thermocouple can be disconnected and the pen run down to room temperature without moving the contacts. On the other hand, if the batteries or any other part of the relay should give out dur-

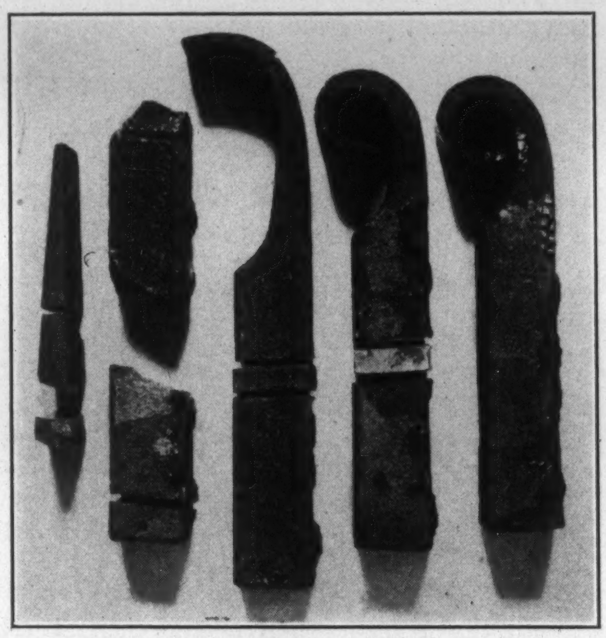

Fig. 2—Malleable Cast Iron—Stages in Annealing

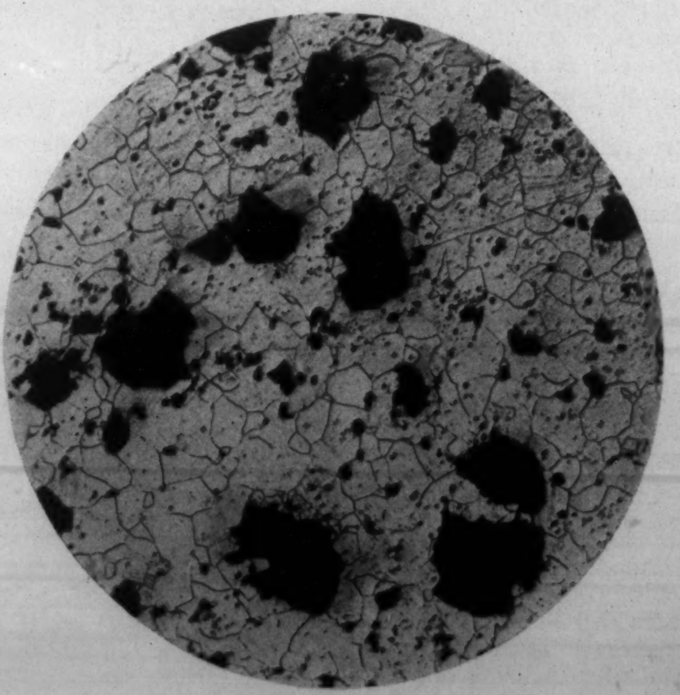

Fig. 3—Malleable Cast Iron. × 100

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[1] Asst. Prof., Dept. of Metallurgical Eng., McGill University, Montreal.

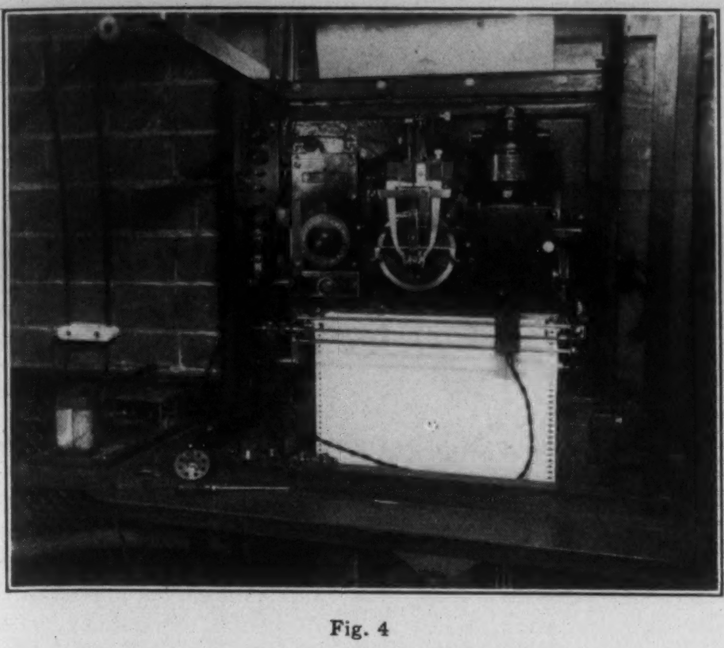


Fig. 4

ing a run, the furnace would be liable to overheating and, in equipment always used for controlling, the pen might well be on the "high" side of the contacts and the switch be made to open by gravity, so that in case of failure of the relay the furnace would get only minimum current.

Another protection that the controller affords is against failure of the thermocouple; by setting the zero of the galvanometer pointer just off-center to the left, an "open" in the thermocouple circuit will cause the pen to move against the contacts and cut the current to minimum. To ensure this, the tension of the suspension and the periodicity of the pointer must be correct.

The construction of the controller is fairly clear from the photographs, Figs. 4 and 5. The platinum-tipped relay contacts are carried by a rectangular fibre block that slides on two rods across the width of the record. In the fibre block, also, is a nut, through which passes a threaded rod. This screw is driven by a train of gears from the record feed cylinder, and slowly moves the block and contacts to give controlled cooling or heating. One intermediate gear gives cooling and two gears reverse the screw and give heating. Disengaging the gears at any point gives constant temperature control. The gear box and the rods are carried by sheet brass brackets attached to the main frame of the recorder by existing screws and nuts. There is no interference with the swinging out of the main frame, nor with any other adjustment or function of the recorder, except that the record feed cylinder is moved slightly to the right to make room for a thin gear. The rods are of $^5/_{32}$" Monel metal (which happened to be in stock) and the gearing is of Meccano parts. The forms of the brackets are shown by the actual size templates Fig. 6 and by the photographs.

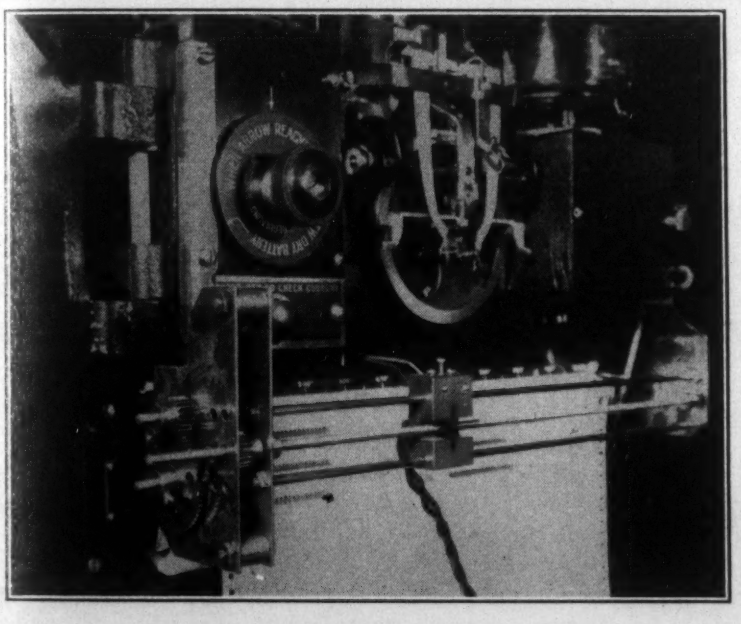


Fig. 5

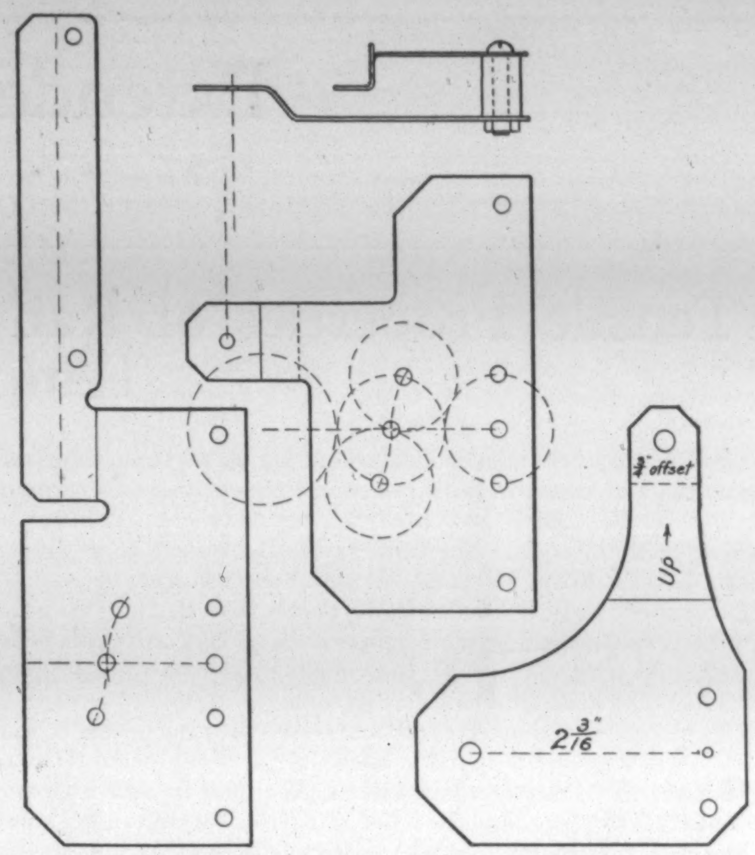


Fig. 6—Templates for Brackets, and Plan of Gear Box. Full Size

As mentioned above, the relay switch is a home-made mercury well affair; no doubt a variety of superior types are available. An interesting feature of ours is the connection of two microfarad condensers across the double mercury gap; these enable it to break 10 Amps, 220 Volts, with a scarcely visible spark.

And here is a tip that may sometime help a reader: in a emergency we found ourselves without recorder ink. With some Carter's Hektograph ink, water, glycerine and a little alkali, we doped up an ink that has proved very satisfactory: it always marks, and neither dries up nor blots when the recorder is idle, summer or winter.

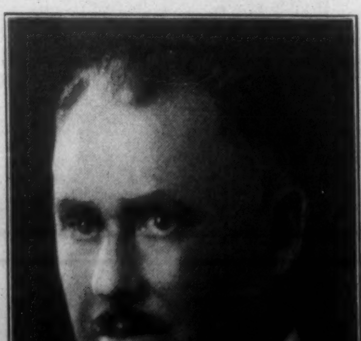
Clyde E. Williams

Clyde E. Williams and **Oscar E. Harder** have been appointed Assistant Directors of Battelle Memorial Institute, Columbus, Ohio.

Mr. Williams has had wide experience in the Bureau of Mines, the Columbia Steel Corporation, etc., in smelting, foundry practice, electric furnace problems, ore concentration and fuel preparation and utilization. He is guiding the work along those lines at Battelle Memorial Institute.

Dr. Harder has specialized in chemistry, geology and metallurgy having been Professor of Metallography at the University of Minnesota for the last eleven years, and has carried on a consulting pratice. He has paid much attention to physical metallurgy, metallography, dental metallurgy, high temperature properties, nitriding, etc. He will guide the work on physical metallurgy at Battelle.

Both men have many publications to their credit, and are active in technical societies. Mr. Williams is Field Secretary of of the Iron and Steel Division of the American Institute of Mining & Metallurgical Engineers. Dr. Harder is a national Director and Howe medallist of the American Society for Steel Treating.



O. E. Harder

Extended Abstract

Selected articles that appear to be of outstanding importance or interest will be abstracted in this section at greater length than Abstracts of Current Metallurgical Literature. The important points will be given fully enough to obviate for the purposes of most readers, the necessity of going to the original article, but in a distinctly condensed form. These abstracts are not critical.

Tensile Properties of Rail and Other Steels at Elevated Temperatures[1]

The Bureau of Standards has been studying for some time past the problem of fissure in rails. A recent paper by J. R. Freeman, Jr. and G. W. Quick presented to the American Institute of Mining & Metallurgical Engineers[2] gives the results of studies of the properties of rail steels at elevated temperatures.

The paper really consists of two parts, that dealing with the properties of steel at elevated temperatures, especially rail steels, as indicated by the title and that dealing with the temperature gradients that exist in a rail during cooling.

The presence of shatter cracks in rails and other steels is well known. It is believed by many that they are the nuclei of transverse fissures. Shatter cracks have been found in new rails and are believed to represent the relief of thermal stresses developed during the cooling of the rail. It was suggested to the Bureau that a study be made of the tensile properties of rail steels at elevated temperatures with particular reference to the blue-heat range. This has been done. Fortunately the tests were carried to higher temperature ranges.

Fig. 1 shows the results of tensile tests on specimens taken from the head and base of a rail.

It will be noted that the tensile strength-temperature curve is normal. There is a slight decrease in tensile strength through the blue-heat range followed by a slight rise at 300° C. and then a uniform decrease in strength with increasing temperatures. At 600° C. the tensile strength is about 40,000 lbs./in.^{2}, or approximately one-third the strength at normal atmospheric temperature. This curve is typical of tensile strength curves of all heats of rail steels studied.

The curves showing change of elongation and reduction of area through the blue-heat range are typical of steel in this range of temperature. The ductility decreases slightly at first with increase in temperature, then rises. The ductility of steel is usually considered to continue to increase with increasing temperature above the blue-heat range. In this case, however, it will be noted that the ductility decreases very rapidly between 400 and 600° C. reaching a minimum at about 650° C. In fact the ductility at this temperature is even slightly less than at atmospheric temperatures. Then as the temperature of test approaches the transformation range the ductility again increases very rapidly reaching the high values usually found in the austenitic range.

The presence of such a low ductile range of temperature in rail steels had not, to the knowledge of the authors at the time the work was, done been previously studied although its presence is pointed out by the authors in the work of some earlier investigators.

The authors have called this phenomenon "secondary brittleness" and the temperature range the "secondary brittle range" to distinguish it from the well-known blue brittle and hot short temperature ranges. As brought out more fully in the paper the property of secondary brittleness is apparently a property of the heat and is not a peculiarity of any one rail or ingot in a heat. (See Fig. 2)

Annealing the steel above the transformation temperatures tends to decrease the magnitude of the effect and even annealing the steel below the Ac$_1$ but above the secondary brittle range also tends to decrease the magnitude of the effect. (Fig. 1) It will be noted that annealing, in this case at 800° C., caused a pronounced increase in the values of elongation and reduction of area of the steel in the secondary brittle range.

Secondary brittleness was found in all rail steels tested but varied greatly in magnitude. Fig. 1 shows one of the most pronounced cases.

Fig. 3 shows results of tests of a heat in which secondary brittleness was least marked of any tested. Here, also, the pronounced effect of annealing on secondary brittleness is illustrated.

As previously stated shatter cracks have been found in new as well as serviced rails and are believed by many to be the primary source of transverse fissures. It was, therefore, of great interest to determine if transverse fissured rails could show secondary brittleness.

Fig. 4 shows the results of tests on a rail which failed by transverse fissure after only 5 months in track. The rail also showed shatter cracks. It is evident that secondary brittleness was present to a marked degree. Results of similar tests on another fissured rail in which the degree of secondary brittlenesss is less pronounced are given in the paper. (Fig. 5)

The authors emphasize the fact that the phenomenon of secondary brittleness is not only prevalent to a more or less marked degree in rail steels but may also be present in many other carbon and alloy steels.

They call attention to work done by Welter in Germany and DuPuy in France several years ago. (Fig. 6) Secondary

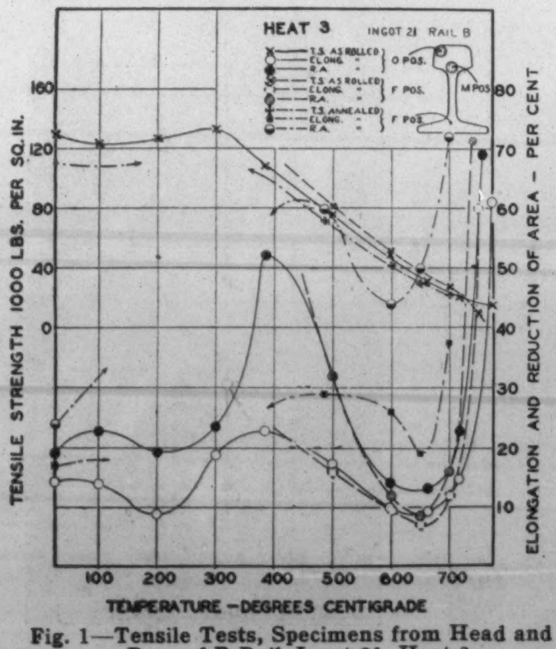


Fig. 1—Tensile Tests, Specimens from Head and Base of B Rail, Ingot 21, Heat 3

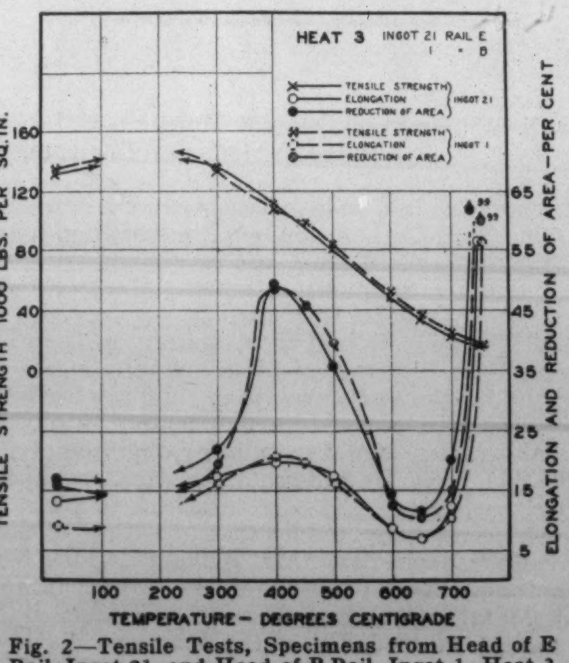


Fig. 2—Tensile Tests, Specimens from Head of E Rail, Ingot 21, and Head of B Rail, Ingot 1, Heat 3

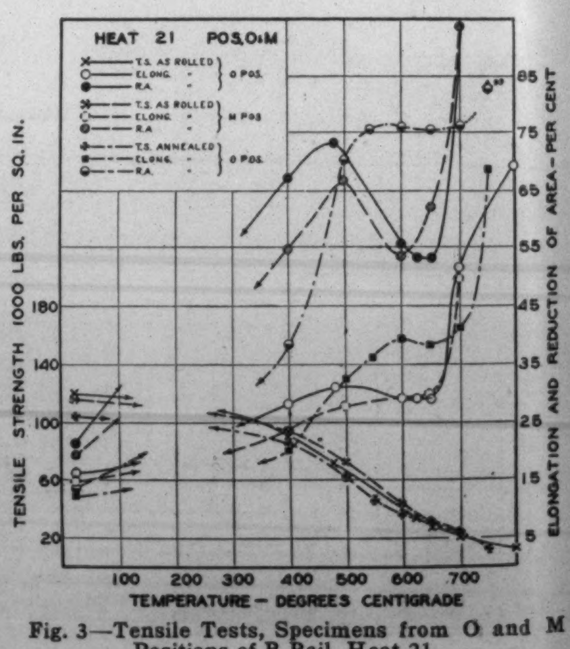


Fig. 3—Tensile Tests, Specimens from O and M Positions of B Rail, Heat 21

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[1] The Original Paper, "Tensile Properties of Rail and Some Other Steels at Elevated Temperatures," J. R. Freeman, Jr. and G. W. Quick, appears in *Bureau of Standards Journal of Research*, Vol. 4, April 1930, pages 549–591.

[2] A. I. M. M. E., *Technical Publication* No. 269, 1930.

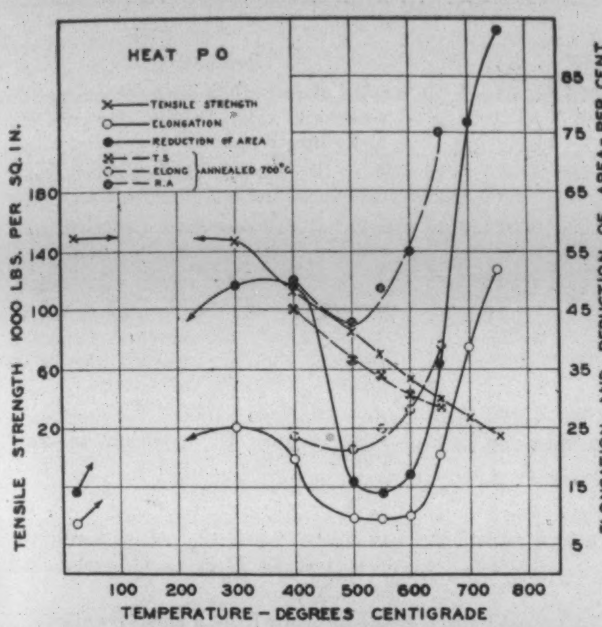

Fig. 4—Tensile Tests at Elevated Temperatures, Specimens from O Position, Transversed-Fissured Rail (PO) from Pennsylvania Railroad

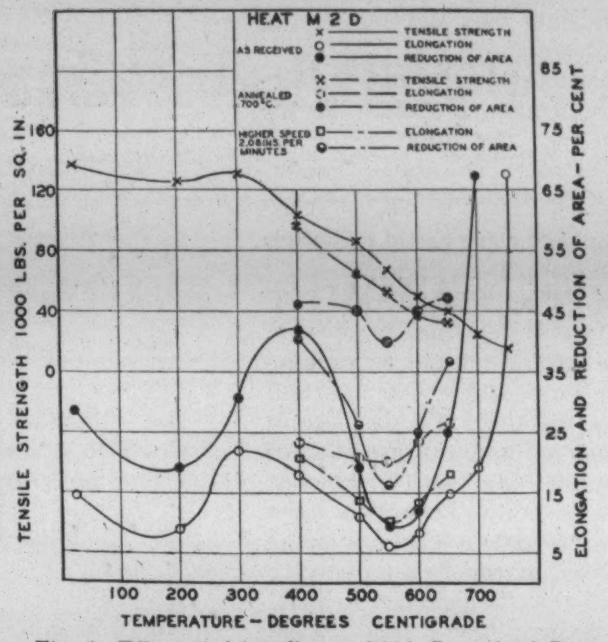

Fig. 5—Effect of Annealing at 700° C. and of Rate of Application of Stress on Secondary Brittleness in Medium Manganese Rail Steel

brittleness is also shown to be present in a relatively pure iron such as ingot iron as indicated by the work of the Japanese investigator, Inokuty, and also by that of Rawdon and Berglund. The authors' tests confirmed their results as shown in Fig. 7. Incidentally the data by Inokuty also bring out very clearly the relation of the secondary brittleness to the blue-heat and hot short range. Results of similar tests on high carbon and alloy steels in which secondary brittleness was found are given in the paper.

That secondary brittleness is not always present, however, is shown by results of tests of some bar stock of approximately rail steel composition. As is evident in Fig. 8 no evidence of secondary brittleness was found.

It is stated that shatter cracks in rails unquestionably represent the relief of internal stress developed in the rail at some stage of manufacture. Evidence to the effect that shatter cracks must form during the cooling of the rail after leaving the hot saw is quoted from work of other investigators. They are said to be intercrystalline in nature indicating that they occur while the steel is hot. It is shown in the paper that fracture in the secondary brittle range is principally intercrystalline. A probable relation of shatter cracks to intercrystalline failure in the secondary brittle range is discussed.

The second part of the paper gives the results of tests to determine the magnitude of the thermal gradients that may exist in a rail under widely different cooling conditions including cooling in still air, moving air, quenching in hot and cold water and interrupted quenching. The tests were all made on a 130-lb. rail section. The curves showing the temperature gradients that exist in a rail of this weight during cooling in still air are of special interest.

This first group of curves shows the temperatures existing during cooling in still air. (Fig. 9). Of special interest are the large temperature gradients that exist in the rail when the center of the head is in the secondary brittle range. It will be noted that when the center is at 650° C. the edge of the base is at 470° C. and the surface of the head at 600° C.

Under somewhat more rapid conditions of cooling similar results were obtained. (Fig. 10) In this case the air stream from an electric fan was directed on the head of the rail during cooling. It should be noted that the effect of the more rapid rate of cooling in air has been simply to increase the slope of the cooling curves without causing any appreciable change in the temperature distribution.

Based upon the fact that temperature gradients produce internal stress as evidenced by the visible bending of rails on the hot beds during cooling, the dilation of steel as it passes through its transformation temperature, the intercrystalline nature of shatter cracks, the similar intercrystalline failure of rail steel in the secondary brittle range a detailed discussion is presented in the paper showing that shatter cracks in rails are probably the result of thermal stresses developed during cooling when the *center* is in the secondary brittle range. It is pointed out that if this be true the development of shatter cracks will depend primarily upon the degree of secondary brittleness and the rate of cooling of any particular rail. It is suggested that slow cooling of rails or other unsymmetrical sections through the secondary brittle range so as to eliminate thermal stresses in this temperature range would be a desirable procedure as a guard against formation of shatter cracks.

Results of these tests are also given in the paper showing the very large temperature gradients that may exist in the head of a rail or similar section during quenching in water.

Figure 11 shows this quite clearly. It is of special interest to note the marked temperature gradient that exists between the point $^1/_4$" under the surface and the center of the section as well as the extremely rapid cooling of the surface. It is evident that a peripheral shell of appreciable area has cooled to temperatures at which the steel attains high strength and rigidity before the center has even entered the transformation range. This relatively rigid case in resisting the stresses imposed upon it by the thermal contraction of the center may quite readily cause internal rupture especially as the center cools through the secondary brittle range. The fact is emphasized that secondary brittleness may be the source of internal failure in many steel sections other than rails in

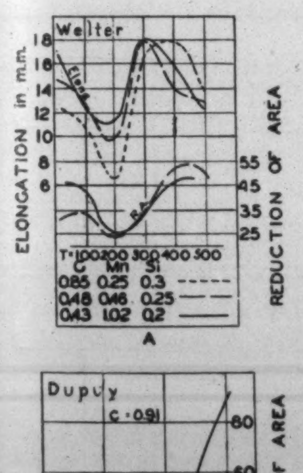

Fig. 6—Tensile Tests Made by (A) Welter and (B) Dupuy

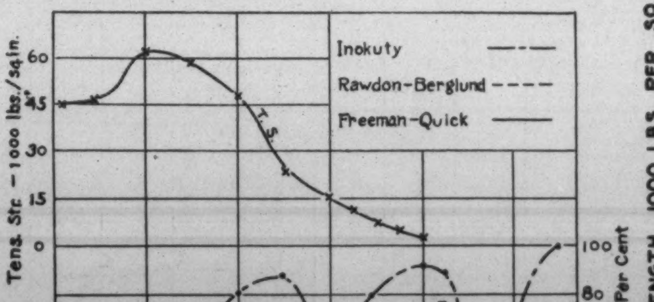

Fig. 7—Tensile Tests at Elevated Temperatures, Armco Iron, by Inokuty, Rawdon and Berglund, Freeman and Quick

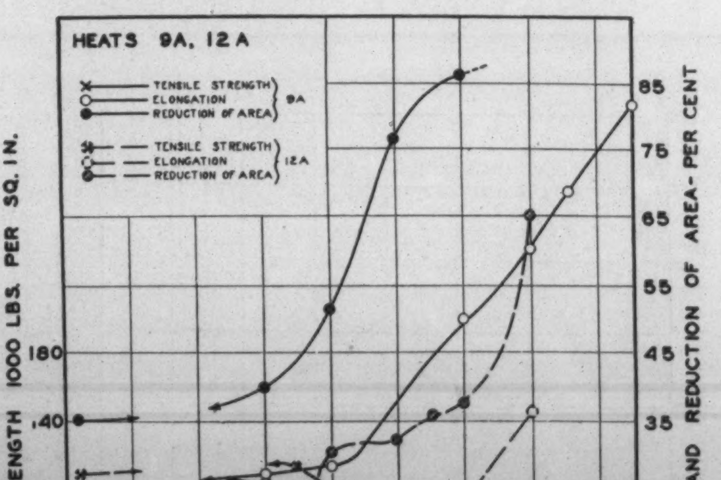

Fig. 8—Tensile Tests, Bar Stock Heat 9A, Approximately Rail Steel Composition, and Heat 12A, 0.98 % Carbon Steel

which similar large temperature gradients may develop during cooling.

It is unfortunately not yet possible to state the cause of secondary brittleness. Certain indicated causes are cited in the paper.

Summary and Conclusion

The authors made a study of the tensile properties of rail steels and some other steels at elevated temperatures. Special study was made of the tensile properties in the approximate temperature range of 400–700° C. They found that the ductility of all rail steels, as measured by percentage elongation and reduction of area, decreases with increase in temperature over a portion of this temperature range. In some instances the decrease in ductility is marked, the elongation and reduction of area values becoming less between approximately 500 and 650° C. than at normal atmospheric temperatures. The same phenomena have been found to exist in Armco iron, a 1% carbon steel and some alloy steels. This range of temperature, in which low ductility becomes manifest, has been termed the "secondary brittle" range to distinguish it from the well-known "blue brittle" range occurring at 200–300° C. and the "hot-short" range which is usually associated with the A_3 transformation and high sulphur content. The phenomenon has been termed "secondary brittleness."

The degree of secondary brittleness varies markedly between individual heats and the temperature of the maximun effect also varies.

The data indicate that the secondary brittleness is not confined to individual rails or ingots but apparently is a property of of the heat as a whole. It has been shown that the degree of secondary brittleness is decreased by annealing at a temperature (700° C.) slightly below the Ac_1 transformation as well as at the usual annealing temperatures above the Ac_3 transformation.

The cause of secondary brittleness has not been determined. Residue analyses and analyses for nitrogen content indicate that the phenomenon is not related to silica, alumina or nitrogen contents. Some evidence has been obtained which indicates that it may be related to the MnO content or free carbides.

Data are also given in the report on the rate of cooling and temperature distribution in a 130-lb. P. S. section rail during cooling in still air, moving air and during quenching in cold and hot water.

A hypothesis as to the formation of shatter cracks in rails, based on the phenomenon of secondary brittleness and temperature distribution during cooling, is presented. Rapid cooling through the secondary brittle range is believed to cause the formation of shatter cracks in rails showing secondary brittleness. Shatter cracks are believed by many to be the nuclei of transverse fissures. It is, therefore, suggested that the origin of transverse fissures is related to secondary brittleness and rate of cooling of the rail.

The fact that secondary brittleness is found in other steels than rail steels suggests that other types of unexplained failures, such a internal cracks in ingots or forgings, may be due to secondary brittleness.

Material Studied

Heat No.	Chemical Composition C	Mn	P	S	Si	Remarks
3	0.69	0.21	0.040	0.020	0.19	100-lb. B rail killed with Al, poured in sink-head ingot molds, new rail for Canadian Pacific Rwy
11	0.64	0.68	0.020	0.020	0.15	100-lb. B rail standard practice, new rail, for Canadian Pacific Rwy.
21	0.70	0.71	0.020	0.030	0.16	100-lb. B rail standard practice, new rail for Baltimore & Ohio RR.
9A	0.60	0.65	0.050	0.025	0.12	3/4" × 2 1/4" bar stock. Annealed. Source not known.
12A	0.98	0.39	0.024	0.019	...	3/4" × 2 1/4" bar stock. Annealed 800° C.—1/2 hr. Cooled slowly in furnace. Source not known.
H1C	0.73	0.60	0.026	0.050	0.25	Ladle analysis from Pennsylvania RR. From "O" position of new 130-lb. heat treated C rail Quenched 30 seconds.
H2C	0.74 0.74	0.63 0.62	0.024 0.043	0.070 0.063	0.31 0.31	Ladle analysis from Pennsylvania RR. From "O" position of new 130-lb. heat treated C rail. Quenched 15 seconds.
H3C	0.82 0.60	0.67 0.66	0.023 0.040	0.040 0.033	0.34 0.32	Ladle analysis from Pennsylvania RR. From "O" position of new 130-lb. C rail.
M1D	0.66 0.66	1.53 1.59	0.030 0.054	0.057 0.046	0.29 0.29	Ladle analysis. From "O" position of new 130-lb. C rail.
M2D	0.59 0.59	1.21 1.30	0.022 0.053	0.045 0.044	0.21 0.20	Ladle analysis. From "O" position of new 130-lb. C rail.
CN1	0.85	0.72	0.030	0.040	0.13	From "O" position of 100-lb. B rail failed in service due to transverse fissure from Canadian National Rwy.
CN2	0.75	0.73	0.030	0.04	0.24	From "O" position of 100 lb. A rail from adjoining position in track to CN1—same service but not fissured.
PO	0.82	0.82	0.033	0.04	0.24	From "O" position of 130 lb. C rail failed after approximately 5 months service due to transverse fissure. From Pennsylvania RR.
PH1	0.68	0.79	0.021	0.029	0.16	From "O" position of rail from reheated bloom after service on Pennsylvania.
PH2	0.52	0.74	0.023	0.020	0.16	From "O" position of direct rolled rail from same heat as PH1.
ST1	0.46	0.62	0.025	0.016	0.27	Locomotive tire steel from Standard Steel Works Co.—cooled in air. Other elements present, Cr 0.8 Mo 0.22.
ST2	0.44	0.62	0.028	0.017	0.27	Same as ST1 but slowly cooled after forging. Other elements present, Cr 0.83, Mo 0.23.
E-1	0.45	1.70	0.024	0.010	0.16	Special manganese-molybdenum rail from Molybdenum Corporation of America. Other elements present, Mo 0.38.
S-17	0.62	0.73	0.047	0.050	0.15	Ladle analysis. Heat poured very hot Rail steel.

The data indicated that equalization of temperature and slow cooling of rails and other steel shapes through their secondary brittle range are desirable procedure to follow in order to prevent formation of shatter cracks.—Richard Rimbach.

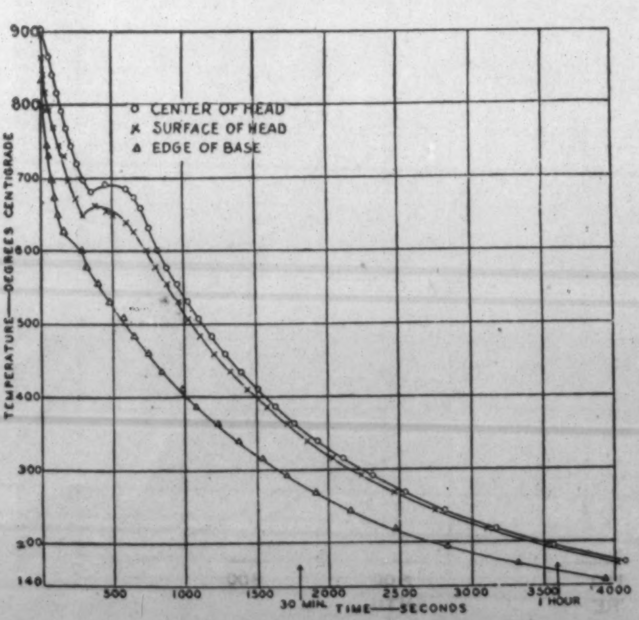

Fig. 9—Temperature-Time Curves, 130-lb. Rail Section, Cooling in Still Air. Run 1

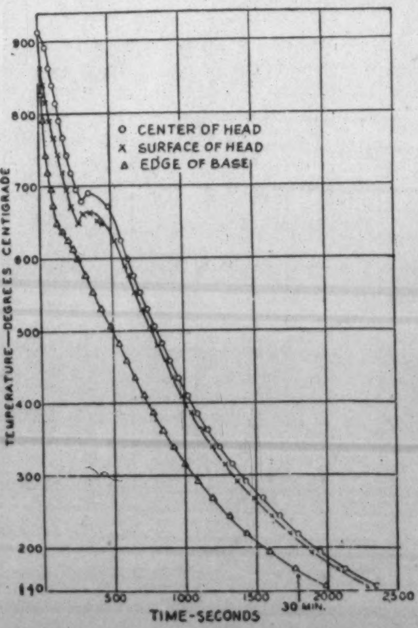

Fig. 10—Temperature-Time Curves, 130-lb. Rail Section, Cooling in Moving Air. Run 2

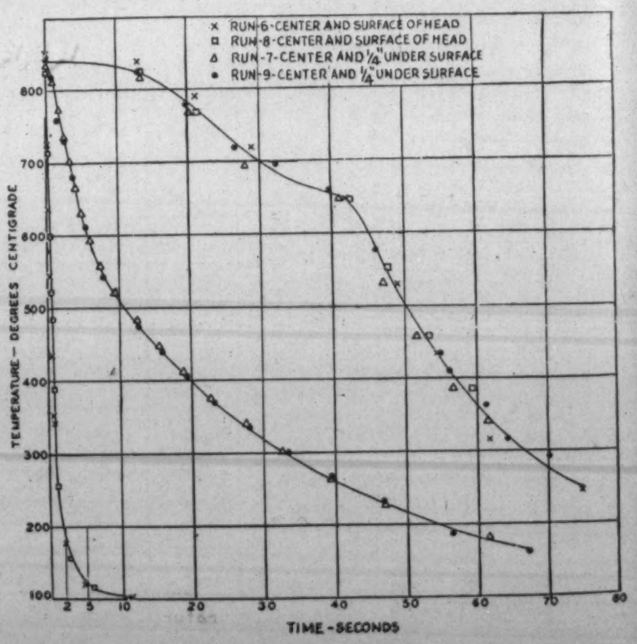

Fig. 11—Temperature-Time Curves, Surface, Center and Intermediate Position in Head of Rail During Quenching in Cold Water. Runs 6, 7, 8 and 9

Correlated Abstract

Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts reviewing the work recently reported pertaining to certain subjects. These reviews will take into consideration the work of a number of workers.

The Cementite Solubility Line

This is one of the series of papers and correlated abstracts relating to parts of the Iron-Carbon diagram which are still in doubt. Earlier ones in the series, by Ellis and Krynitsky, together with editorial comment, appeared in the April issue, and one by Dowdell in the May issue.

Problems Involving the A_{cm} Line

Yensen's recent work[1] which led him to conclude that extremely pure iron possesses no allotropic transformations, has probably caused many of us to wish for a critical redetermination of the whole iron-carbon diagram. Yensen drew his conclusion largely from an analogy with the iron-silicon alloys which show no transformations, having observed that the less carbon his iron contained the less silicon was required to eliminate the transformations. According to Yensen's view silicon raises the A_3 point in iron not because silicon is more soluble in α than in γ iron as is generally assumed, but because it eliminates oxygen present in solid solution. From the foregoing, a rather direct connection may be drawn between this subject and one of the problems involving the cementite solubility or A_{cm} line, namely that of normal and abnormal steel.[*, 2, 3, 4]

The microstructural differences between carburized normal and abnormal steel have been attributed on the one hand to the effects on the A_{cm} line and the A_1 transformations of dissolved or submicroscopic particles of oxides, and on the other to the effects of alloying additions.[4] For instance, manganese is known to induce structural normality; this result may be considered to be due either to the deoxidizing effect of manganese or to the "alloying" effect of manganese in lowering the transformation points. Aluminum is considered to cause structural abnormality; it is also a deoxidizer, although a much stronger one than manganese, but it raises the transformation points. It is interesting to note that the relations of the iron-carbon diagram appear to be such that the presence of a third element which raises the A_3 point also raises the A_{cm} line.[5]

Carbon and nickel which lower the A_3 transformation tend to produce a more normal structure whereas molybdenum, chromium, vanadium, phosphorus and silicon which raise the A_3 transformation all appear to cause more or less structural abnormality. It would appear, therefore, from the data at hand that a very plausible case could be made out explaining structural abnormality (exclusive, however, of abnormality in commercial plain carbon carburizing steels) as due to the presence of elements which raise the A_3 point and likewise the A_{cm} line. It would be interesting to test this surmise in the case of elements whose effects on normality are unknown, say, copper and tin, the former of which lowers the A_3 point, whereas the latter is stated to raise it. As a matter of fact there is little good evidence available whereby we may separate the effect on the transformations and on normality of an alloying element from the possible effect of the oxide of that element.

A critical determination of the A_{cm} line in pure iron-carbon alloys would do much to clarify this vexing problem which at present is not amendable to very direct means of study. Of course, a determination of the effects of oxides on the A_{cm} line, such as has already been attempted[6] and of the various alloying elements mentioned, in specimens free from oxide, would also be needed, but the first requisite is a truly reliable A_{cm} line.

Another aspect of the same problem pointed out by Sefing,[7] which is also of general importance, is that particles of oxides or dissolved oxygen and certain alloying elements, affect the temperature at which austenite becomes completely homogeneous. It is well known that in vanadium, molybdenum, chromium and other alloy steels the maximum heating temperature (T_{max}) has a considerable effect on the position of the transformation points. It is quite likely that the A_{cm} line is similarly affected.

The influence of oxygen in increasing diffusion of the cementite below the A_2 transformation was emphasized by Grossmann;[7] in fact he based a proposed mechanism for the formation of the abnormal structure on this effect. He assumed that dissolved oxygen makes cementite more soluble in iron and explained the formation of coalesced cementite by what might be termed the spheroidizing or diffusion phenomenon, according to which small bodies of cementite go into solution in the ferrite, quickly diffuse through it, and then precipitate out on any larger undissolved cementite masses which may be present, or perhaps on some inclusions which may serve as centers for precipitation. As was pointed out in discussion of this paper, however, this sort of diffusion and precipitation occurs in both normal and abnormal steel not only in the ferrite, that is at temperatures below the A_1 point, but also in the austenite at temperature considerably above the A_1 point.

This phenomenon would, therefore, seem to be connected with differences between normal and abnormal steel in the solubility of cementite in austenite; in other words with the position of the A_{cm} line. Of course, the coalescence of the cementite may really be caused by "differentials of solubility" due to non-uniformities or micro-segregations of oxides, but still the effect on the A_{cm} line is there. Herty, et al.[4] have suggested that variations in the degree of undercooling between normal and abnormal steel may play a part in causing the observed differences in microstructure. This may be so, but that undercooling is not the sole factor is evidenced by the fact that upon heating below the A_1 point, where undercooling cannot enter in, abnormal steel spheroidizes more readily than normal steel.[3] The question of "differentials of solubility" and diffusion must be carefully considered in determining the A_{cm} line, for it may prove a troublesome factor in disturbing the attainment of equilibrium. A stimulating discussion of another side of the subject of diffusion was aroused by the work of Kelley.[8] The contributions by Benedicks and Hultgren[9] were of very great general interest, but that of Hoyt touched rather closely upon this particular problem. He went so far as to suggest that diffusion phenomena may account among other things, for grain growth, ghost lines and grain refinement. A general survey of the influence of oxygen and nitrogen on the iron–carbon system was recently made by Gillett.[10]

We may now turn to the relation between the A_{cm} line and carbides; with the latter, of course, the line may be considered to deal primarily. Gat[7] has dwelt at some length upon the point that we are not sure of the composition of cementite. This is true even in plain carbon steel, although his suggestion that the cementite in abnormal steel may be an iron-carbon-oxygen complex appears to be rather far fetched. It is particularly true of steels alloyed with the so-called carbide forming elements such as manganese, chromium, tungsten and vanadium. We can recognize the carbides under the microscope but have only a very inaccurate knowledge of how much iron, manganese or chromium, for instance, they contain. A determination of the A_{cm} line and of the effect of alloying elements upon it may be expected to throw considerable light on this problem which is of great importance in regard to the whole subject of the alloying of steel, from the standpoint of corrosion resisting as well as mechanical properties.

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[1] T. D. Yensen, "Pure Iron and Allotropic Transformations," *Transactions American Institute Mining & Metallurgical Engineers, Iron and Steel Division*, 1929, page 320.

[*] It will be recalled that in carburized normal steel the hyper-eutectoid zone shows well-formed pearlite grains surrounded by thin cementite envelopes, whereas in the hyper-eutectoid zone of abnormal steel the pearlite is broken down and large masses of coalesced cementite are present, surrounded by ferrite.

[2] E. W. Ehn, "Influence of Dissolved Oxides on Carburizing and Hardening Qualities of Steel," *Journal Iron & Steel Institute*, Vol. 105, 1922, page 157.

[3] S. Epstein and H. S. Rawdon, "Steel for Casehardening—Normal and Abnormal Steel," *Bureau of Standards Journal of Research*, Vol. 1, 1928, page 423.

[4] C. H. Herty, B. M. Larsen, et al. "Abnormality in Case-Carburized Steels," *U. S. Bureau of Mines, Coöperative Bulletin* No. 45, 1929.

[5] M. A. Grossmann, "Nature of the Chromium-Iron-Carbon Diagram," *Transactions American Institute Mining & Metallurgical Engineers*, Vol. 75, 1927, page 214.

[6] O. E. Harder and W. S. Johnson, "Solubility of Carbon in Normal and Abnormal Steels," *Transactions American Society Steel Treating*, Vol. 15, No. 1, 1929, pages 49–68.

[7] Discussion of Grossmann's paper, "On Oxygen Dissolved in Steel and Its Influence on the Structure," *Transactions American Society Steel Treating*, Vol. 16, July 1929, page 19.

[8] F. C. Kelley, "Grain Growth in Metals Caused by Diffusion," *Proceedings Institute of Metals Division, American Institute Mining & Metallurgical Engineers*, 1928, page 390.

[9] A. Hultgren, *Institute of Metals Division, American Institute of Mining & Metallurgical Engineers*, 1929, page 591.

[10] H. W. Gillett, "The Unknown Influence of Oxygen and Nitrogen on the Iron–Carbon System," METALS & ALLOYS, Vol. 1, Nov. 1929, page 237.

It is noteworthy that in considering the increasing solubility of cementite in austenite with increasing temperature we are accustomed to disregard the probable converse effect of the increased solubility of austenite into cementite. That there may be such an effect, possessing very important practical consequences, is indicated by the work of Schwartz[11] who was able to speed up most remarkably, the decomposition of cementite in white cast iron into graphite upon annealing, by prequenching. Possibly the apparent curvature of the A_{cm} line which has been observed by investigators may be due in part to an increased solubility of austenite in cementite at higher temperatures.

Technique

Two articles, one by Rosenhain[12] and one by Masing[13], both presented in a finely lucid style, appeared recently on methods of research in metallography. Without going into the subject in any detail, some matters of technique which affect the determination of the A_{cm} line will be mentioned.

Foremost comes the question of the preparation of pure iron-carbon alloys. The work of Yensen has set a standard in this respect which may be well nigh unattainable. To obtain pure iron, the first method which suggests itself is to melt electrolytic iron in vacuum in an induction furnace and then to anneal for a lengthy period in hydrogen to remove oxygen and carbon—the assumption being that any occluded hydrogen can later be removed by subsequent annealing in vacuum. Yensen states, however, that it is doubtful whether oxygen in solution is removed by hydrogen. Possibly hydrogen introduced over molten iron would be more effective. Also, during annealing of solid iron in hydrogen, the gas could be radiated with ultra-violet light from a mercury arc[14] to give some atomic hydrogen which should be more active in reducing oxygen and carbon. It might be supposed, since for the determination of the A_{cm} line only the higher carbon alloys are needed, that the oxygen in electrolytic iron could be reduced with carbon. This is true. However, the work on normal and abnormal steel has indicated that we cannot be certain that oxygen is absent from even high carbon steels. It would seem better, therefore, if a method is perfected of making pure iron, to use this material as a base and obtain the higher carbon alloys by carburizing with an oxygen free gas like acetylene,[15] if that is possible. Such a method would serve particularly for determining the effect of oxygen, for in one case oxygen bearing iron could be used and in the other oxygen free iron. An interesting method for preparing the pure metals of which volatile compounds are known ($FeCl_2$ for iron) by heating a filament of the metal in an atmosphere of the vapor of the compound has recently been described.[16] Once the alloys have been prepared the question arises of retaining constancy of composition during the run. This is especially difficult since carbon volatilizes rapidly in vacuum at the relatively high A_{cm} temperatures. It is apparent that all of these matters are intimately related to the most urgent problems at present confronting the chemical and physical metallurgist in the ferrous field.

Assuming that we have prepared our alloys the next step is to choose the best methods of studying them. Thermal analysis, the most fundamental method, is practically useless for a determination of the A_{cm} line, the thermal effect of the solution of cementite being too small, if a slow rate of heating or cooling such as is necessary to attain equilibrium, is used. Microscopic examination either after quenching from the equilibrium temperature, or after etching at that temperature is probably one of the best means of study, although it suffers from the fact that small residual amounts of cementite may be difficult to detect. Also when quenching is used one cannot be sure that no change has taken place during the short interval required to cool the sample. Magnetic analysis has been tried[17] but apparently this method does not give sharp enough indications of the limit of cementite solubility. The electric resistance method and the differential dilatometric method described in the articles by Rosenhain and Masing are particularly well adapted for the determination of the A_{cm} line. They both have the advantage that the measurement can be made at any stationary temperature and no particular rate of change of temperature is necessary. Thus equilibrium conditions can be more nearly approximated. The differential dilatometer devised by Konno[18] has in the hands of Sato,[19] recently given apparently very accurate indications of the cementite solubility line. Electric resistance measurements on the other hand did not give very definite breaks in the curves.[20] It appears that the differential dilatometric method in conjunction with microscopic examination is probably the best adapted for determining the A_{cm} line.

It is of interest to note that recently[21] the limit of solid solubility of the $CuAl_2$ compound in duralumin has been obtained by X-ray measurements of the changes in lattice parameter upon aging. Apparently these measurements are considered accurate enough to be used as a basis of an argument against the theory that the age hardening of duralumin is caused by the precipitation of $CuAl_2$. It is doubtful, however, whether X-ray methods would prove useful in determining the A_{cm} line. The temperatures would have to be much higher which would make the experimental conditions more difficult and also decrease the accuracy of the lattice parameter measurements.

Next to the preparation of homogeneous and pure iron-carbon alloys the most important problem in determining the A_{cm} line, as in all such work, is that of attaining equilibrium. With lengthy annealing periods the composition of the alloy is liable to change as has been mentioned, but probably an equally serious difficulty would arise from "diffusion" resulting in spheroidization or coalescence of the cementite. In this regard we may benefit from the wealth of experience which has been gained in determining the solid solubility lines of the compounds of aluminum in the light aluminum alloys.[22] In order to reach equilibrium more rapidly it has been found advantageous to quench these alloys from a high temperature and then to reanneal at the desired lower temperature. This method should be suitable for iron-carbon alloys, assuming, of course, that during heating to the high quenching temperature constancy of composition of the alloys can be retained.

The electric resistance and differential dilatometric methods lend themselves to indirect methods for ascertaining the approach to equilibrium. The rate of change in electrical resistance, for instance, upon heating at different temperatures could be plotted. The curves obtained far above the equilibrium temperature should be different from those nearer that temperature. Such rate curves might also throw some light on the kinetics of the reaction which occurs, i.e., whether it appears to be monomolecular or otherwise and hence would be of general interest. Sato[19] using the differential dilatometer obtained critical points at different temperatures under different rates of heating and cooling. To determine the equilibrium temperature he drew curves through these points and extrapolated to zero rate. Masing[13] has described other resources of this nature which may be used.

Existing Determinations

The results of the earlier determinations of the A_{cm} line are well summarized by Tschischewsky and Schulgin[23] and are given in the accompanying figure. These are due principally to Roberts-Austen,[24] Carpenter and Keeling,[25] Heyn,[26] Gutowsky[27] and Wark[28] and were based largely on microscopic examination. As may be seen in the figure the results obtained by the various investigators showed very considerable divergence. None of them seems to be sufficiently precise to fulfill our present needs. Howe in discussing Tschischewsky's paper considered that Gutowsky's determinations deserved great weight. These were the homogeneity of the specimens being given. Gutowsky's four points are indicated by crosses in the figure. They lie somewhat to the left of the straight line drawn by Tschischewsky. The latter obtained only two points by his method of etching in vacuo and they are probably of no very high degree of accuracy. He placed the eutectoid composition at 0.9% C. (at 700° C.) and the limit of cementite solubility in austenite at 1.7% (at 1130° C.). Upon drawing a straight line between these limits he found that his two points were near this line.

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[11] H. A. Schwartz, "Graphitization of Prequenched White Cast Iron," *Transactions American Society Steel Treating*, Vol. 17, March 1930, page 383.

[12] W. Rosenhain, "Some Methods of Research in Physical Metallurgy," *Journal Institute of Metals*, Vol. 42, No. 2, 1929, page 31.

[13] G. Masing, "Methods of Research in Metallography," *Journal Institute of Metals*, Vol. 42, No. 2, 1929, page 69.

[14] H. S. Taylor, "Chemical Reactions of Hydrogen Atoms," *Journal American Chemical Society*, Vol. 48, 1926, page 2840.

[15] G. Takahasi, "On the Relation Between the Quantity and the Depth of Carburization," *Science Reports Tohoku Imperial University*, Vol. 17–6, 1928, page 1135.

[16] A. E. van Arkel, "Separation of Metals from the Gas Phase," *Chemish Weekblad*, Vol. 24, 1927, pages 90–96; *British Chemical Abstracts*, 1927 (A), page 375.

[17] Honda and Endo, "On the Magnetic Determination of the Solidus and Solubility Lines in the Iron–Carbon System," *Science Reports Tohoku Imperial University*, Vol. 16, 1927, page 235.

[18] S. Konno, "A Study of the A_1 and A_3 Transformation in Carbon Steel by Means of a Differential Dilatometer," *Science Reports Tohoku Imperial University*, Vol. 12, 1923, page 127.

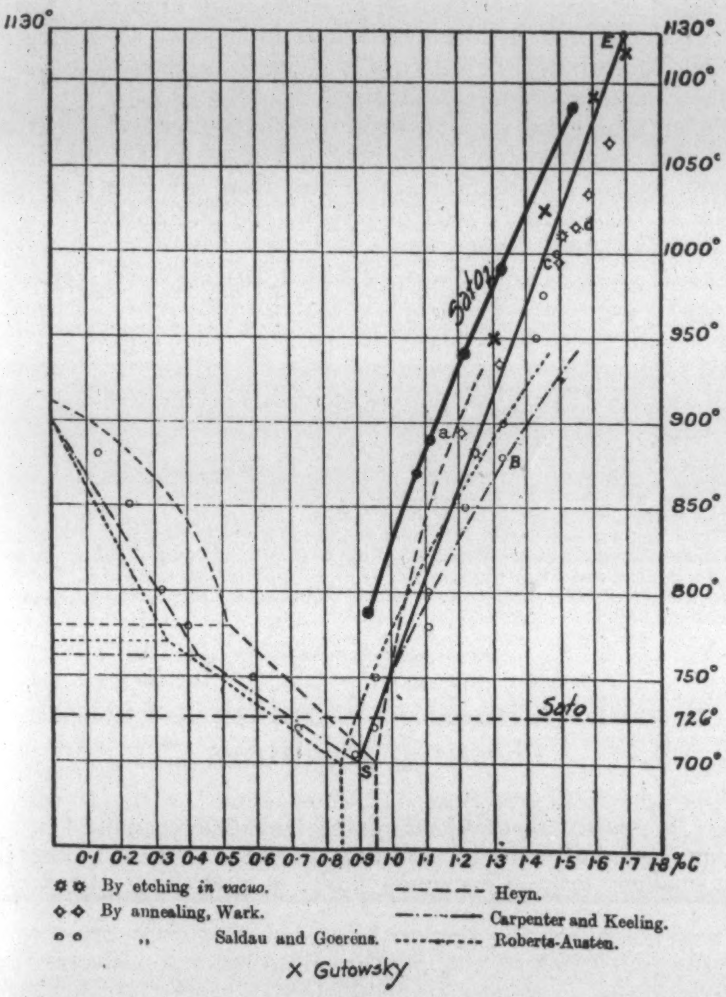
[19] T. Sato, "On the Critical Points of Pure Carbon Steels," *Technical Reports Tohoku Imperial University*, Vol. 8, 1929, page 27.

[20] Kaya, "On the Solidus Line of the Iron–Carbon System," *Science Reports, Tohoku Imperial University*, Vol. 14, 1925, page 529.

[21] F. von Goeler and G. Sachs, *Metallwirtschaft*, Vol. 8, 1929, pages 671–680.

[22] E. H. Dix and F. Keller, "Equilibrium Relations in Aluminum Magnesium Alloys," *Institute Metals Division, American Institute Mining & Metallurgical Engineers*, 1929, page 351.

[23] N. Tschischewsky and N. Schulgin, "The Determination of the Line SE of the Iron-Carbon Diagram by Etching Sections at High Temperature in Vacuo," *Journal Iron & Steel Institute*, Vol. 95, part 1, 1917, page 189.



Since then a considerable amount of work on the cementite solubility line has been conducted by Honda and his co-workers culminating in the publication of Sato previously mentioned. His results appear to be of very high precision and probably represent the best determinations we have. He obtained the curved line indicated in the accompanying figure, using the differential dilatometer. The specimens were prepared by melting electrolytic iron with carbon electrodes in an alumina crucible in an Ajax-Northrup induction furnace, the runs being made in vacuo.

It will be observed in the figure that he changed the usual position of the A_1 line to 726° C. He does not appear to have determined the eutectoid composition, however, which is still somewhat vague. Campbell[29], in agreement with Belaiew puts it at between 0.8 and 0.9% carbon. Wark[28] states Heyn sets the eutectoid point at 0.95% carbon.

Sato's highest carbon alloy was 1.55% (in equilibrium at 1080° C.) so that he did not determine the saturation value of carbon in austenite. The best value of this we have at present is probably that of Gutowsky[27] at 1.7% carbon at 1130° C. It should be noted that since both the solidus and A_{cm} line are curved the point of intersection of the two cannot be placed very definitely. Gutowsky set the above value mainly on the basis of the curve he obtained for the times of eutectic arrest of the higher iron-carbon alloys, the first appearance of eutectic in quenched alloys giving no very certain indication. Rosenhain[12] has pointed out, however, that the curve of the times of eutectic arrest cannot be relied on in setting the equilibrium limit of solid solubility because of undercooling which always occurs.

All of the foregoing will indicate that there is still a great deal to be done on the A_{cm} line. It will be evident too, that anyone who perfects a sufficiently refined technique for doing it, might as well go the whole way and redetermine the entire iron-carbon diagram. It would be almost too much to ask of any one man or group also to determine the effects of the alloying elements and their oxides.—S. Epstein

Announces Correct Use of "Carborundum"

The Carborundum Company of Niagara Falls, N. Y., in its campaign against the growing tendency on the part of authors to treat the word "Carborundum" as a common or generic noun, announces that the word "Carborundum" is a trade-mark of this company, registered in the United States and many foreign countries and is applied by it to its range of products: abrasive, refractory, mechanical and electrical. The Carborundum Company states that the proper term is silicon carbide and that this is the form that should be used in articles, texts, references, etc., unless a specific Carborundum Brand product is referred to. If the word "Carborundum" is used it should always begin with a capital letter and be put in quotation marks to denote its trademark significance.

Increased Molybdenum Production in 1929

Four companies produced molybdenum ore in the United States during 1929, the Climax Molybdenum Co., at Climax, Colorado, the Molybdenum Corporation of America at Sulphur Gulch, near Questa, New Mexico, the Southern Copper Mining Co. at Helvetia, Arizona, and the Minerals & Metals Corp., near Sahuarita, Arizona, according to data collected by the United States Bureau of Mines, Department of Commerce.

In 1929 a total of 419,400 short tons of ore was milled yielding 3854 tons of concentrates, carrying from 75.40–88.33— molybdenum sulphide. In addition, a small tonnage of ore carrying 16% of molybdenum sulphide was produced and sold without milling. The metallic molybdenum content of the concentrates and ore so produced was 4,020,607 lbs., an increase of 17% over 1928. The shipments of concentrates and ore from the mines contained an equivalent of 3,904,648 lbs. of elemental molybdenum valued, more or less arbitrarily, at $2,259,000 at the mines.

Calendar of Meetings

Association of Iron & Steel Electrical Engineers, Buffalo, N. Y., June 16–20.

American Railway Association Convention, Atlantic City, N. Y., June 18–25.

World Power Conference, Berlin, Germany, June 16–25.

American Society for Testing Materials, Haddon Hall, Atlantic City, N. J., June 23–27.

Society for the Promotion of Engineering Education, Montreal, Canada, June 26–28.

International Exposition at Liége, Belgium, Chemical and Engineering Sessions, Sept. 14–21.

Sociéte dé Chimie Industrielle, Liége, Belgium, Sept. 21–27.

National Metal Congress and Exposition, Hotel Stevens, Chicago, Ill., Sept. 22–27.

American Society for Steel Treating, Annual Convention, Chicago, Ill., Sept. 22–27.

Institute of Metals Division of American Institute of Mining and Metallurgical Engineers, Annual Fall Meeting, Chicago, Ill., Sept. 22–27.

Iron and Steel Division of American Institute of Mining and Metallurgical Engineers, Annual Fall Meeting, Chicago, Ill., Sept. 22–27.

Iron and Steel Division, Machine Shop Practice Division American Society of Mechanical Engineers, Annual Fall Meeting, Chicago Ill., Sept. 22–27.

American Welding Society, Annual Fall Meeting, Congress Hotel, Chicago, Ill., Sept. 22–27.

British Cast Iron Research Association, London, England, Oct. 29.

American Gas Association, Atlantic City, N. J., Oct. 13–17.

Association for the Advancement of Science, Cleveland, Ohio, Dec. 29–Jan. 31, 1931.

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[24] Roberts-Austen, "Fifth Report of the Alloys Research Committee," *Proceedings Institute Mechanical Engineers*, 1899, page 44.

[25] Carpenter and Keeling, *Journal Iron & Steel Institute*, 1904, No. 1, page 224.

[26] E. Heyn, "Metallographische Untersuchungen von Eisenlegierungen," *Verhandlungen des Vereins zur Beförderung des Gewerbfleisses*, 1904, page 355.

[27] Gutowsky, *Metallurgie*, Vol. 6, 1909, page 731.

[28] H. J. Wark, *Metallurgie*, 1911, page 104.

[29] Campbell, *Journal Iron & Steel Institute*, 1908, III, page 318.

Critical Abstract

Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts of a critical nature on articles of special importance. The current literature will be covered in the Abstracts of Current Metallurgical Literature.

Corrosion-Fatigue

In the various investigations of McAdam, Speller, Rawdon, Fuller, Harvey and others who have worked on corrosion-fatigue problems in this country, rotating beam or repeated bending tests have been employed. In these tests, the most highly stressed portion of the bar is at the outside, and damage naturally progresses from the outside in.

Very little has been done in corrosion-fatigue testing with axially loaded specimens in which the whole cross-section is uniformly stressed. A recent investigation at the Royal Naval College, Greenwich, by Haigh and Jones[1] was, however, carried out on the Haigh axial loading machine.

In studying broken fatigue specimens of lead, they found indications that the failure started from the inside instead of the outside and that the internal cracks so formed were discolored, as if by oxidation. Even though the cracks at no point reached the surface, but were only found by taking specimens that had not yet failed out of the fatigue testing machine and breaking them open, yet the surfaces of the cracks seemed oxidized.

This observation led to the hypothesis that the starting of the cracks was really due to a sort of corrosion-fatigue by attack of oxygen during repeated stress. We know, of course, that corrosion of steel by water goes on faster under repeated stress than without stress, but the idea of air-corrosion *inside* a metal specimen is new and rather startling.

To check up on the idea, tests were made under oil. A pure lead which failed in about $5^1/_2$ million cycles in the air at $^1/_4$ ton/in.^{2} ran $11^1/_2$ million unbroken at $^1/_4$ ton/in.^{2} in oil and was then run in oil at higher stresses for many more cycles. Lead specimens alloyed with a little tin and cadmium, or with a little bismuth, were then similarly tested with equally striking results. In these specimens, if the test was made at a stress above the endurance limit, and the test stopped before failure, internal cracks were found but their faces were bright. This verified the belief that air diffused into the specimen when the tests were made in air, but did not when they were made in oil.

A thin grease coating gave results intermediate between those in air and in the oil bath.

A bath of distilled water was then tried, and at a stress that in air produced failure after 0.6 million cycles, the life under water was some 7 – $7^1/_2$ million. It was deduced that oxygen diffused in from water more rapidly than from oil, but much less rapidly than from air, hence an aqueous bath retarded corrosion-fatigue of lead instead of causing it.

In this connection a test is cited on steel of 0.33% C which, tested in air at room temperature, showed an endurance limit of 41,000 lbs./in.^{2}, and tested in distilled water at 96° C., showed 38,500 lbs./in.^{2}, the reduction in endurance limit being very slight compared to that which would have resulted had cold water been used. The hypothesis is that since oxygen is less soluble in hot water than in cold, the "corrosion-fatigue" in cold water is due to oxygen rather than to water.

To test the oxygen hypothesis with lead, it was decided to try a depolarizer, i. e., to generate hydrogen at the surface of the metal so it might combine with oxygen before it could enter the metal. Hence a lead specimen with an air endurance limit of 0.2 ton was tested in a bath of normal acetic acid. The surface of the specimen was corroded, yet the specimens ran $11^1/_2$ million cycles unbroken at 0.25 tons/in.^{2} and $8^1/_2$ at 0.35 tons/in.^{2}

If, however, the surface was only moistened with the acid, by a wick feed, so that the film of acid was too thin to keep the oxygen out, then the endurance was slightly lower than in air.

Haigh, therefore, concludes that so-called corrosion-fatigue is not due to surface roughening from corrosion, but rather to the diffusion into the metal from the reagents of substances such as oxygen which "provoke chemical or physical change under cyclic stress."

It has been rather generally supposed that the deterioration of the specimen in a corrosion-fatigue test was due to the water itself, or the salt or acid in the solution.

Speller, however, pointed out in 1926, in discussing one of McAdam's papers[2] that hydrogen penetration along grain boundaries may play a part in the corrosion-fatigue of steel. In 1928, he[3] again referred to concentration cells set up in minute fissures in the metal due to local variations in oxygen concentration, though this would more naturally refer to aqueous solutions of oxygen than merely to the gas itself.

Fuller[4] found that a jet of steam blowing on a nickel steel specimen in air lowered the endurance limit from 55,000 lbs./in.^{2} to 20,000, while in a steam chamber free from air (the condensed steam containing only 0.02% oxygen) the endurance limit remained at 55,000.

The effect of gaseous reagents is thus already being considered by workers on corrosion-fatigue. Haigh's idea that the damage may be due more particularly to the gases that diffuse into the metal than to mere surface attack offers a rather novel point of view, and one that will require experiments on more alloys before the value of the conception can be determined.—H. W. GILLETT.

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[1] **B. P. Haigh and B. Jones, "Atmospheric Action in Relation to Fatigue in Lead,"** ***Preprint*** **No. 521 for March, 1930,** ***Meeting of British Institute of Metals.***

[2] L. N. Speller, Discussion, *Proceedings American Society Testing Materials*, Vol. 26, 1926, II, page 276.

[3] L. N. Speller, I. B. McCorkle and P. F. Mumma, "Influence of Corrosion Accelerators and Inhibitors on Fatigue of Ferrous Metals," *Proceedings American Society Testing Materials*, Vol. 28, 1928, II, page 159.

[4] T. S. Fuller, "Endurance Properties of Steel in Steam," *Technical Publication* No. 294, *American Institute Mining & Metallurgical Engineers* February 1930.

World's Largest and Smallest Fatigue Testing Machines

Charles Winninger, Star of "Show Boat" with its dreamy "Ole Man River" melody, examining the world's smallest fatigue testing machine. He is standing beside the world's largest. The smallest tests a specimen 0.05″ in diameter; the largest 2.25″.

These machines, together with intermediate sizes, are used by the research laboratories of the Westinghouse Electric and Manufacturing Company to insure that the best possible metal is obtained for use in their apparatus—whether it be a tiny household fan or a giant powerhouse generator.

Abstracts of Current Metallurgical Literature

These abstracts are not critical, but merely review developments as they are recorded.

PROPERTIES OF METALS

Molybdenum and Its Compounds. W. G. Cass. *Industrial Chemist* Oct. 1929, Vol. 5, pages 429–431.

A brief description of the minerology, technology and chemistry of molybdenum is given.

The Relation Between the Tensile Strength and the Hardness of Steel. O. Schwarz. Technical Memorandum, National Advisory Committee for Aeronautics.

Translation of "Zugfestigkeit und Härte bei Metallen" by O. Schwarz, *Zeitschrift des Vereins deutscher Ingenieure*, June 8, 1929, pages 792–797. See Metals & Alloys, Sept. 1929, page 132.

Production and Some Properties of Large Iron Crystals. N. A. Ziegler. *Technical Publication* No. 273, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 17 pages.

Flat tensile samples and ring samples of iron containing very large crystals were produced by slight deformation followed by annealing at 850° C. The mechanical properties of such samples differed considerably from iron of ordinary grain size and the properties varied with the orientation of the grains. The magnetic permeability of a single crystal sample is many times higher than that of a polycrystalline sample. JLG

Working Properties of Tantalum. M. M. Austin. *Technical Publication* No. 278, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 8 pages.

A bar of pure tantalum can be cold rolled without annealing from 0.4" to 0.001". When it is necessary to soften during working the metal can be annealed at 500° C., but a thorough anneal requires a temperature of 800 or 1000° C. The properties of the metal change as it is contaminated with gases. Samples that have had a prolonged heating in a vacuum tube have the hardness of annealed copper, and the usual commercial metal has the hardness of annealed mild steel. Examples of deformation of coarse grained metal are shown. JLG

PROPERTIES OF NON-FERROUS ALLOYS

P.-M.-G. A New Alloy. *Iron and Coal Trades Review*, Nov. 1929, Vol. 119, page 715.

A substitute for gun metal, phosphor bronze, etc. See Metals & Alloys, March 1930, Vol. 1, page 245. RHP

Thermal Conductivity of Copper Alloys. Cyril Stanley Smith. *Technical Publication* No. 291, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 24 pages.

This is the first of a series of experiments to determine accurately the thermal conductivity of copper alloys. The literature has been completely reviewed. Apparatus constructed for the measurements is described and it is estimated that values accurate to within 2% or less are obtained. The thermal conductivities of copper-zinc alloys containing from 0 to 50% zinc were determined. The thermal conductivity for copper was determined as 0.941 cal/cm.^{2}/cm./sec./° C. at 20° C. With the addition of zinc the conductivity falls to a minimum at 39% zinc and then increases with the appearance of the beta phase. Electrical conductivities were also determined and the Wiedemann-Franz ratio calculated. This ratio increased with increasing zinc content in the alpha range. Conductivities of some special brasses are also given. JLG

PROPERTIES OF FERROUS ALLOYS

Austenitic Steels. Albert Sauveur. *Fuels & Furnaces*, Sept. 1929, Vol. 7 pages 1365–1366.

Ni-Cr austenitic steels of the 18–8 and 8–18 types offer the following superiorities over non-austenitic steels: greater resistance to corrosion at room temperature, to corrosion, scaling and particularly "creep" at elevated temperatures, and to wear; absence of brittleness at all temperatures, including the "blue heat range"; absence of effects of heat treatments which injure other steels; and remarkable retention of their strength at elevated temperatures. Tests indicate that the superiority as to strength increases rapidly with temperature increases. MS

Modern Cast Irons. J. G. Pearce. *Iron & Coal Trades Review*, Nov 8, 1929, Vol. 119, page 714. Mechanical World (*Manchester*), Vol. 86, Nov. 15 & 22, 1929, pages 464–465 and 480–482.

Abstract of a paper read before the Diesel Engine Users Association, London, Nov. 1, 1929. Discusses the testing of properties of cast iron as shown by the tests specified by the British Engineering Standards Association. Recent work has shown that the structure of cast iron is governed by melting conditions as well as by composition and by rate of cooling. RHP

High Elastic Limit Structural Steels. J. A. Jones. *Blast Furnace & Steel Plant*, Nov. 1929, Vol. 17, pages 1664–1667; Condensed, *Rolling Mill Journal*, Oct. 1929, Vol. 3, pages 439–442; *Journal Iron & Steel Institute*, 1929, Vol. II, page 127–146.

From Paper before Iron & Steel Institute, Sept. 1929. See Metals & Alloys, Feb. 1930, Vol. 1, page 383. MS

Silicon Steel for Transformer Sheets. J. H. Hruska. *Blast Furnace & Steel Plant*, Nov. 1929, Vol. 17, pages 1652–1655. Condensed, *Iron & Coal Trades Review*, December 6, 1929, Vol. 119, page 874.

Si deoxidizes and degasifies molten steel, rendering the metal more homogeneous and magnetically more efficient. Numerous tests indicate that 0.01% Si in steel with not more than 0.12% C. decreases watt losses 0.0011 w. per kg. at room temperature. Presence of 0.01% Cu in steel with 4.1% Si increases watt losses 0.0058 w. per kg. at room temperature. Insufficient deoxidation is far more important factor in increasing watt losses. Production of satisfactory steel requires careful supervision of all operations. A higher grade of metal is secured in furnaces of smaller capacity than in larger ones. In contrast with low C sheets, high Si steel does not "age" magnetically. In high grade silicon sheets there should be absence of non-metallic inclusions, the absolute sizes of crystallites should be 0.25–0.40 mm. measured on the surface of the sheet, and the crystallites should have a smooth non-rugged outline. MS & RHP

Expansion Properties of Low-Expansion Fe-Ni-Co Alloys. Howard Scott. *Technical Publication* No. 318, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 34 pages.

Alloys of the invar type were modified by the addition of cobalt, together with a modification of the nickel content and their expansion over an extended temperature range determined. The addition of cobalt increases the range of low expansivity. The substitution of cobalt for part of the nickel yields an alloy with a lower expansion than invar at ordinary temperatures. The effect of small amounts of manganese and carbon were also determined. Equations are given whereby the optimum compositions can be found for low expansion over various temperature ranges.

Properties of Corrosion-Resisting Alloys. P. S. Menough. *Blast Furnace & Steel Plant*, Nov. 1929, Vol. 17, pages 1648–1651, 1655; Dec. 1929, pages 1810–1815. *Heat Treating & Forging*, Nov. 1929, Vol. 15, pages 1437–1440, 1450; Dec. 1929, pages 1567–1572.

Deals with Cr and Cr-Ni steels. Cr in amounts up to 12% and more, reduces materially the amount of C held in the eutectoid composition; raises the critical temperature; lowers the rate of diffusion of C through the steel above the critical range; slows down the rate of removal by heat treatment of cold working strains; and in the stainless range renders the steel air hardening. In high-Cr alloys, corrosion resistance and machinability are increased by keeping C low. Higher C steels are just as resistant to oxidation at high temperatures. Higher Cr steels have a tendency to grain growth, which cannot be prevented or materially reduced by heat treatment. If heated for a long time at 800–1000° F., and slowly cooled, 28–30% Cr steels and some of higher Cr–medium Ni steels become very brittle when cold. Bars of 28–30% Cr can be bent cold, but if notched they will break short. In lower Cr steels this is not so pronounced. Stainless iron and the stainless steels resist sea water and atmospheric corrosion. Against acids and salts 16–18% Cr steel is used, with 0.15% C. for rolled sections, and 0.45% C for castings. Heat treatment to break up pearlitic structure brings out maximum corrosion resistance. For resistance to temperatures up to 2100°F. and high temperatures in atmospheres containing S, 28–30% Cr steels are used. Cr steels can be successfully welded with a Cr steel rod in a neutral or slightly reducing oxyacetylene flame or with an electric arc. They can be readily machined. A high-C high-Cr alloy has been developed for abrasion resistance. Commercial Ni-Cr steels are austenitic and work harden very readily, causing great abrasion resistance. They can be readily welded with the oxyacetylene flame or electrically. They have little tendency to grain growth or brittleness after heating. Their toughness makes machining difficult. Alloy with 18% Cr–8% Ni resists corrosion by many agents. The 24% Cr-14% Ni steel has the additional advantage of retaining its strength to 2000° F. The 15% Cr-35% Ni steel is particularily useful where high strength at elevated temperatures is desired. It is not as resistant to S atmospheres as the 24% Cr-12% Ni, and is very difficult to forge or roll as compared with the other alloys. An austenitic alloy known as X has recently been developed which has some remarkable high temperature properties. All these steels can be cast in molds to most any desired shape, but many difficulties arise particularly with sand molds. For best results casting should be designed so there will be a minimum of shrinkage strains and no heavy sections so located that it is impossible to feed them as they freeze. MS

Progress in the Metallurgy and Utilization of Wrought Iron. J. S. Tinham. Paper read before a joint meeting of the Staffordshire Iron & Steel Institute, Birmingham Metallurgical Society & Midland Section of the Institute of Metals, Dudley, England, Nov. 5, 1929, 25 pages; *Iron & Coal Trades Review*, Nov. 15, 1929, Vol. 119, page 754; Nov. 22, 1929, page 789.

In the introduction the author briefly considers the production and marketing of wrought iron in England. The elastic properties are considered in detail and compared with mild steel.

CHEMICAL ANALYSIS

	Netherton Best Yorkshire Iron	Mild Steel
Si	0.09	0.15
S	0.02	0.05
P	0.100	0.046
Mn	0.04	0.67
C	0.02	0.12

PHYSICAL TESTS

	lbs./ins.^{2}	lbs./in.^{2}
Limit of Proportionality	36,500	29,500
Yield Point	40,500	45,000
Ultimate Strength	47,500	65,000
Elongation (5")	35%	29%
Reduction of Area	51%	64%
Modulus of Elasticity	29 million	29 million

The rates of recovery of wrought iron and mild steel were compared by overstraining to the yield point, resting for 2$^1/_2$ hrs. without load and then testing to destruction. For results see table:

Wrought Iron	Yield Point lbs./in.^{2}	Ultimate Stress lbs./in.^{2}	Elong. %	R. of A. %
Original Bar	35,000	50,000	32.5	54
2$^1/_2$ hrs. rest after overstrain	34,000	50,000	32.0	52
Mild Steel				
Original Bar	49,000	67,000	29.0	65
2$^1/_2$ hrs. rest after overstrain	28,500	66,800	25.0	62

The ultimate strength of good wrought iron is not appreciably reduced up to 750° F. If the strength at 70° F. is taken as 100 the corresponding strength at higher temperatures is shown in the table, compared with 28–32 tons tensile steel and copper containing 0.15–0.35% As:

RETENTION OF STRENGTH AT HIGH TEMPERATURES

Temp. ° F.	Wrought Iron	Mild Steel	Arsenical Copper
70	100	100	100
210	104	103	93
400	112	132	80
570	116	122	66
750	96	86	46
900	76	49	—
1100	42	28	—

A table shows the applications of wrought iron in engineering. Corrosion of wrought iron is considered. A table lists a number of wrought iron structures with their erection dates. The American developments are briefly considered. RHP

Changes in Physical Properties of Iron-Silicon-Carbon Alloys Produced by Various Heat Treatments. T. D. Yensen. *Fuels & Furnaces*, Oct. 1929, Vol. 7, pages 1613–1614.

Abstract of paper read before Iron and Steel Institute, Sept. 1929. See Metals & Alloys, Feb. 1930, Vol. 1, page 383. MS

The Relative Safeties of Mild- and High-Strength Steels Under Fatigue Stresses. J. B. Kommers. *Chemistry & Industry*, Dec. 20, 1930, Vol. 48, pages 1223–1227.

This article presents arguments against some of the conclusions drawn by B. P. Haigh in his paper entitled "The Relative Safeties of Mild- and High-Tensile Alloyed Steel under Alternating and Pulsating Stresses," which appeared in *Chemistry & Industry*, Jan. 11, 1929. A reply by Prof. Haigh to these arguments is appended. Prof. Kommers emphasizes the fact that "even though the softer steels may have some advantage over high-strength steels in being able to adjust themselves to conditions involving concentration of stress due to drilled holes, this conclusion must be strictly limited to the case in which the stresses are not reversed." When the stresses are reversed he points out that the softer steels give approximately the same results as the higher strength steels. GN

The Brittle Range in 18 and 8 Chromium-Nickel Iron. H. H. Lester. *Transactions American Society for Steel Treating*, Nov. 1929, Vol 16, pages 743–770; *Iron & Steel Industry*, Oct. 1929, Vol. 2, page 24.

Paper presented before the Eleventh Annual Convention, American Society for Steel Treating, September, 1929. Includes discussion. Austenitic chromium-nickel iron, (18% Cr, 8% Ni, with less than 0.1% C) suffers a considerable loss in ductility upon being heated to 1300° F. It is suggested that the critical point found at 1330° F. upon heating and 1148° F. upon cooling in the specimens studied is associated with this loss of ductility. The explanation advanced is that precipitation of alpha iron crystals and carbides of iron and chromium occurs along the atomic (slip) planes in the austenite grains. To account for this precipitation, as well as for the occurrence of the critical point upon heating, it is postulated that the austenite as it exists at room temperature is intrinsically unstable, an increase in temperature and mechanical working being favorable to its decomposition. WHK

CORROSION, EROSION AND PROTECTION OF METALS AND ALLOYS

Tarnishing of Non-Ferrous Metals & Alloys. Bernard Jeffs. Houghton's *Black & White*, Feb. 1930, Vol. 2, pages 23–24.

Types of tarnishing are given and its prevention discussed. MLM

The Oxidation of Copper at High Temperatures. (Ueber die Oxydation des Kupfers bei hoher Temperature.) W. Feitknecht. *Zeitschrift für Elektrochemie und angewandte physikalische Chemie*, Jan. 1930, Vol. 36, pages 16–17.

Remarks on the criticism of F. J. Wilkins.

The paper is a reply to the criticism of F. G. Wilkins (*Zeitschrift für Elektrochemie*, 1929, Vol. 35, page 500 of a former paper (W. Feitknecht, *Zeitschrift für Elektrochemie und angewardte physikalische Chemie*, 1929), Vol 35, page 142), in which the fact was set forth that the rate of oxidation of copper in its first stages does not follow the simple parabolic law $X^2 = Kt$. This is due to the fact that the layer of oxide shows a very strong crystal growth, through which the diffusion of oxygen takes place as readily as along the grain boundaries. At the beginning, due to the small grain size, the grain surface is large and the diffusion through this will be comparatively large. As the crystal size increases the diffusion takes place almost entirely through the crystal, thereby obeying the simple parabolic law. The author further states that tests have shown that the values for the initial oxidation as calculated by Wilkins are more than 50 times too high and that this is not explainable by errors in readings during the tests. The portion of the boundary surface diffusion appears to be impossible to calculate exactly inasmuch as this changes quite rapidly. Where the oxide layers are made up of large crystallites, the author agrees with Wilkins that the diffusion, for the most part, takes place through the crystallites. However, with decreasing crystallite size, the portion of the boundary surface diffusion increases. This results also from the dependence of the rate constant K upon the temperature. This constant decreases very slowly with falling temperature, because with smaller crystal growths the granular size is smaller, causing the portion of the boundary surface diffusion increase. AJM

Atmospheric Corrosion of Metals. Third Report to the Atmospheric Corrosion Research Committee. J. C. Hudson. *Transactions of Faraday Society*, Sept. 1929, Vol. 25, pages 476–496.

Gives supplementary data on the continuous corrosion of high conductivity copper and about 15 other metals and alloys, as determined by the electrical resistance method. Up to the present, 80/20 nickel-chromium shows the smallest, and 70/30 copper-nickel the greatest resistance changes. H. C. H. Carpenter briefly reviewed the report and indicated the more important conclusions. C. Benedicks suggested that a factor which ought to be considered is the primary formation of a dew on the test materials. U. R. Evans described some corrosion tests tending to confirm that corrosion is only rapid where the primary corrosion product is a soluble body and sufficient moisture exists to dissolve it and thus remove it a sensible distance from the seat of attack. R. S. Hutton inquired whether the influence of stress had any accelerating effect on atmospheric corrosion. The author, in his reply to the above comments, quoted the results of experiments which, in general, indicated that the effect of surface condition on corrosion is negligible. He agreed with W. S. Patterson that the dischagge of fine ash into the air from power stations will probably have a serious effect upon metal work in the surrounding districts.

The Metal Protection Meeting, Vienna 1929 (Die Metallschutztagung Wien 1929.) Alfred Deinlein. *Elektrotechnik und Maschinenbau*, Dec. 15, 1929, Vol. 47, pages 1105–1109.

Report of joint meeting, with abstracts of papers presented, of the Reichsausschuss für Metallschutz and the Österreichischen Ausschuss für Metallschutz, Oct. 6–10. MS

New Methods of Measuring and their Applications. (Neue Messmethode und ihre Anwendungsmoeglichkeiten.) F. Toedt. *Messtechnik*, Jan. 1930, pages 5–6; *Waerme*, Oct. 19, 1929, page 796–797; *Zeitschrift Veriens deutschenzuckerindustrie*, 1929, Vol. 79, pages 680–695.

The disadvantages of present methods of corrosion testing are given. A new method for the direct indication of corrosion on an electrical indicator is described, as well as its application for testing protecting coatings and for the indication of the content of oxydizing substances.

Durability of Iron Phosphate Coatings. E. M. Baker, A. J. Herzig, & R. M. Parke. *Metal Cleaning & Finishing*, Oct. 1929, Vol. 1, pages 541–543.

Paper before the American Electrochemical Society, entitled "Accelerated Corrosion Tests for Coatings of the Iron Phosphate Type," Sept. 21. See Metals & Alloys, Feb. 1930, Vol. 1, page 385. MS

Steel Characteristics—Forging Furnaces. Walter E. Jominy. *Heat Treating & Forging*, Feb. 1930, Vol. 16, pages 196–201. Condensed, *Fuels & Furnaces*, Nov. 1929, Vol. 7, pages 1691–1694.

Paper before American Gas Association entitled "A Study of Burning and Overheating of Steel," Oct. 14–18 Metallurgical factors involved in heating steel for forging are scaling, decarburization, burning of steel, rate of heating and ease of forging. Discusses his investigation of burning of steel. See Metals & Alloys, Vol. 1, Oct. 1929, page 182; Jan. 1930, page 338. MS

Acid-Resisting Products for Chemical Plant. R. Furness. *Chemical Age*, Aug. 31, 1929, Vol. 21, pages 190–193.

The author indicates broadly the range of acid-resisting materials available for use to-day.

Corrosion of Alloys Subjected to the Action of Locomotive Smoke. F. L. Wolf. *Technical Publication* No. 293, *American Institute Mining & Metallurgical Engineers*, Feb., 1930 16 pages.

Copper alloys were exposed to severe locomotive smoke for 4 years in the smoke stack of a round house and their corrosion determined by loss in weight and change in impact resistance. These tests were compared with the behaviors of catenary clips made of the same materials and used where the atmosphere was contaminated with smoke. An additional test which includes ferrous alloys has been in progress for about a year. JLG

Ceramic Coatings—an Outcome of Corrosion Difficulties in Oil Cracking. J. C. Morrell & W. F. Faragher. *Chemical & Metallurgical Engineering*, Oct. 1929, Vol. 36, pages 596–599.

Discuss corrosion problems in oil industry. Have developed a satisfactory protective coating for cracking vessels comprising 60 lb. furnace cement, 30-lb. white silica foundry sand, $1^1/_2$-lb. short fiber asbestos 1 gal. water-glass (40–43° Bé.) and $1^1/_4$-pt. water per 100 lb. batch. This is applied to the sand-blasted surface in layers $^1/_8$–$^3/_{16}$ in. thick, and it is then brushed with a solution comprising 6-lb. furnace cement, 1 gal. water-glass and 3 pt. water. It is finally cured by heating with gas burners at a prescribed rate to 900° F. MS

Experience Dictates Construction Materials for Handling Corrosive Agents. A. H. Cooper. *Chemical & Metallurgical Engineering*, Dec. 1929, Vol. 36, pages 747–750.

Bibliography of approximately 40 references. Summary of the literature on materials used for H_2SO_4, HCl, HNO_3, $HC_2H_3O_2$, alkalis, NH_4OH and H_2S. MS

Fabrication of Acid-Resisting Steel Plant. W. H. Hatfield. *Iron & Coal Trades Review*, Nov. 1, 1929, Vol. 119, pages 670–671. *Engineering*, (London), Vol. 128, Nov. 1, 1929, page 567; *Journal Society Chemical Industry*, Nov. 1, 1929, pages 1060 1067; *Chemical Age*, Nov. 2, 1929; *Metallurgical Supplement*, pages 31–34; *Chemical Trade Journal*, Nov. 1, 1929, pages 415–417.

Abstract of a paper before the Institution of Chemical Engineers, London, Oct. 25, 1929. Steels having chromium content of 14–20%, nickel 7–12% and carbon not exceeding 0.20% are classed as austenitic. The general compositions of steels produced are chromium 18%, nickel 8% or chromium 15% and nickel 11%. Thermal expansion, hot and cold working, welding, riveting, machining, softening, pickling reagents, foundry work and causes of failure of these acid resisting steels are discussed. RHP

STRUCTURE OF METALS AND ALLOYS

Metallography and Macrography

Super-Structure and Magnetic Susceptibility in the System Copper–Gold. (Ueberstruktur und magnetic susceptibility im System Kupfer–Gold.) H. J. Seeman & E. Vogt. *Annalen der Physik*, 1929, Vol. 2, No. 8, pages 976–990.

Some metallic solid solutions show certain transformation phenomena which take place in a more or less extended temperature range and are accompanied by excessive changes of heat contents and electric conductivity. The system Cu–Au shows such transformations especially in the range of alloys of a composition Cu_3Au and CuAu. Test methods and test results are described in detail and influences due to treatment are taken into account. Cu_3Au showed an increase, CuAu a decrease of the diamagnetic susceptibility after proper arrangement of atoms in the lattice. A theoretical explanation for the different behavior cannot be given yet. Ha

The Alpha-beta Transformation in Brass. Albert J. Phillips. *Technical Publication* No. 288, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 9 pages; *Fuels & Furnaces*, Mar. 1930, Vol. 8, pages 339–340.

The transformation in brasses containing from 60 – 63% copper was investigated by determining the relative amounts of the 2 constituents after different heat treatments. In a brass containing 62% copper, which is entirely beta near the melting point and entirely alpha at room temperatures when in equilibrium, the beta was almost entirely transformed into alpha upon quenching from the beta range. Alloys containing either more or less copper did not transform so completely. This phenomenon is explained as due to the great rapidity of the transformation when there is no change in composition. JLG

Progress Notes on the Iron-silicon Equilibrium Diagram. Bradley Stoughton & Earl S. Greiner. *Technical Publication* No. 309, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 33 pages.

The literature on the iron–silicon system is reviewed and 51 references are given. Results of experimental work to determine possible changes in phase of the alloys containing less than 10% silicon is described. Discontinuities in temperature-electrical resistance curves indicated a change of phase the temperature of which varies from about −100° C. at 2.5% silicon to 450° C. at 6.5% silicon. This change of phase occurs at temperatures at which other authors have found changes in ductility. JLG

Solidification of Cast Irons and Quenched Steels. A. L. Norbury. *Fuels & Furnaces*, Jan. 1930, Vol. 8, pages 93–100.

From paper before Iron and Steel Institute entitled "Constitutional Diagrams for Cast Iron and Quenched Steels," May 1929. See Metals & Alloys, Dec. 1929, Vol. 1, page 288. MS

Alpha-phase Boundary in the Ternary System Copper–silicon–manganese. Cyril Stanley Smith. *Technical Publication* No. 292, *American Institute Mining & Metallurgical Engineers*, 32 pages.

Equilibrium conditions in the copper corner of the system were determined. The addition of manganese lowers the temperatures of the reactions in the binary system copper–silicon. The solid solubility of Mn_3Si decreases with decreasing temperature. The portion of the system investigated is completely indicated by diagrams. JLG

Influence of Rate of Cooling on Dendritic Structure and Microstructure of Some Hypoeutectoid Steel. Albert Sauveur & C. H. Chou. *Technical Publication* No. 299, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 16 pages.

Steel samples of 0.40% C after being melted in an Arsem furnace were allowed to solidify at different rates through the zones of solidification, granulation and secondary crystallization and their macro and micro-structure studied. The behavior of a pure steel containing 0.53% C was also studied and found to have smaller and less well defined dendrites. JLG

Structure and X-ray Analysis

Crystal Structures of Iron and Steel. L. M. Jordan *Heat Treating & Forging*, Nov. 1929, Vol. 15, pages 1441–1443.

First part is a review of H. Gries and H. Esser's work on large iron crystals published in *Archiv für das Eisenhüttenwesen*, May 1929, Vol. 2, pages 749–761. See Metals & Alloys, Aug. 1929, Vol. 1, page 79. Second part deals with Hultgren's and with Herbert's work on super-hardening and its basis in crystalline modification. MS

X-ray Notes on the Iron–Molybdenum and Iron–Tungsten Systems. E. P. Chartkoff & W. P. Sykes. *Technical Publication* No. 307, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 10 pages.

Diffraction patterns of Fe-Mo and Fe-W alloys indicated the changes in lattice dimensions when solid solutions were formed. The compounds formed were of low symmetry, but the exact symmetry was not obtained. Phase changes with heat treatment showed the precipitation of compounds on "age-hardening." The well resolved doublet in the hardest Fe-W alloy indicated that the presence of the precipitated phase rather than a strained condition of the lattice is responsible for increased hardness by heat treatment. JLG

PHYSICAL, MECHANICAL AND MAGNETIC TESTING

Changes in the Dimensions of Metallic Wires Produced by Torsion. Soft Drawn Copper. T. Lonsdale *Philosophical Magazine*, Nov. 1929, Vol. 8, pages 703–713.

This is a report of an investigation of the changes in length which occur when "high conductivity "soft drawn copper wire under various tensions is twisted, the tensions used being too small to produce measurable elongations when acting alone in the absence of torsion. An equation is given expressing the results, which show that considerable elongations are produced, even under very small tensions. For insufficiently annealed wire the elongations are rather smaller, while hard-drawn copper wire contracts as much as 1% on twisting under small tensions.

The Idiosyncrasies of Valve Mechanisms and Their Causes. S. Timoshenko. *Journal Society Automotive Engineers*, Feb. 1929, Vol. 24, pages 227.

Discussion of paper by F. Jehle & W. R. Speller. Defects in mild steel are nowhere nearly as important in their effect upon fatigue properties as they are in the case of steel spring material of a high degree of hardness. Special endurance tests for spring materials are needed because of the condition of twist and shear stress in springs which may not be covered by the data available from ordinary fatigue tests. *—From Abstracts by the A.S.T.M. Research Committee on Fatigue of Metals.*

Relation Between Pressure and Diameter of Impression in Brinell Hardness Test. Kinnosuke Takahasi. *Metal Stampings*, Nov. 1929, Vol. 2, pages 888, 908.

Abstract from Science Reports of Tohoku Imperial University, July 1928. Meyer found the relation $P = ad^n$, where P is the pressure, d the diameter of indentation, and a and n are constants characteristic of the substance. Author studied this relation for pressures from 5–100 kg. Specimens were Al, Cu, Zn, brass and steel. Found that a and n are not constant for entire range of pressures, but decrease with pressure. Value of n tends to equal 2 as the load decreases, and this is the limiting value in the case of plastic deformation. It is 3 in the case of elastic deformation. MS

Endurance Properties of Steel in Steam. T. S. Fuller. *Technical Publication* No. 294, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 13 pages.

Rotating beam cantilever machines have been equipped with a chamber so that specimens may be tested in steam under pressure. A nickel steel had an endurance limit of 45,000 lbs./in.^{2} in air at room temperatures and a limit of 35,000 lbs./in.^{2} in steam at 60 lbs., 150–160° C. Another nickel steel treated to have higher physical properties had the following endurance limits in lbs./in.^{2}: 55,000 in air; 55,000 in steam at 98° C.; 50,000 in steam at 60 lbs., 150–160° C.; and 20,000 in a steam jet in the atmosphere. An endurance limit of 65,000 lbs./in.^{2} was obtained on a nitrided specimen in 60 lbs. steam. JLG

Tensile Properties of Rail and Other Steels at Elevated Temperatures. John R. Freeman, Jr. & G. Willard Quick. *Technical Publication* No. 269, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 48 pages; *Bureau of Standards Journal of Research*, April 1930, Vol. 4, pages 549-591.

Tensile tests on rail steels in which the ultimate tensile strength, elongation and reduction of area were obtained indicated that in most cases there was a marked decrease in ductility at some temperatures between 500 and 650° C. Both the temperature at which this "secondary brittle range" occurs and the magnitude of the decrease in ductility vary for different heats. Other steels, including Armco iron and a hyper-eutectoid steel were found to have this brittle range. The secondary brittleness was less marked after annealing at 700 or 1000° C. Microscopic examinations of portions of test pieces adjacent to the fracture that occurred in the secondary brittle range indicated an intercrystalline shattering of the metal. It is suggested that the rapid and non-uniform cooling of rails through the secondary brittle range may cause shatter cracks and that steels having a pronounced secondary brittle range may tend to produce transverse fissures. Data are given on the rate of cooling and temperature distribution in a rail section during several cooling rates. JLG

Standards for Testing Magnetic Permeameters. Raymond L. Sanford. *Bureau of Standards Journal of Research*, Feb. 1930, Vol. 4, pages 177–188.

The testing of magnetic permeameters is greatly facilitated by the use of calibrated test specimens used as standards. The test method employed for calibration must be an absolute one whose accuracy can be estimated without reference to any other method. In order to be suitable for use as magnetic standards, test specimens must conform to certain requirements the most important of which is magnetic uniformity along their length. The paper gives reasons for adopting the Burrows permeameter as the standard method for calibration, shows the effect of non-uniformity in the specimens, and gives the characteristics of 4 bars which have been found to be sufficiently uniform to warrant their use as magnetic standards.

The Joint Convention of the German and Austrian Associations for the Testing of Materials. (Die gemeinsame Hauptversammlung des Deutschen und des Osterreichischen Verbandes für die Materialprüfungen der Technik.) *Elektrotechnik und Maschinenbau*, Dec. 29, 1929, Vol. 47, pages 1148–1154.

Report of meeting held in Vienna, Oct. 8–11, 1929, with abstracts of papers presented. MS

Methods of Tests for Determining the Machinability of Metals in General, with Results. O. W. Boston. *Transactions American Society for Steel Treating*, Nov. 1929, Vol. 16, pages 659–710; *American Machinist*, Oct. 12, 1929, page 415.

Paper presented before Eleventh Annual Convention, American Society for Steel Treating, September, 1929. Includes discussion. The results of a series of experiments upon 18 ferrous and 21 non-ferrous metals are given. The force on a planer tool, the energy required to remove a chip in milling (results obtained from a single-toothed cutter in an impact type of machine), the torque and thrust on a drill while drilling, and the penetration of a drill under a uniform load, are presented in tables and shown graphically. The author believes that the planer test gives the most consistent and accurate indications of the machining qualities of a given material, although the drill penetration test has the advantages of simplicity and rapidity of application. It is shown that while the Brinell and Rockwell numbers vary almost directly with the physical properties such as the ultimate strength in tension, compression and shear, none of these values bears a simple relation to the machining qualities. However, it is brought in the discussion that various product relations of these properties such as elongation × shear, Brinell × shear, Brinell × elongation, and energy of rupture may be correlated fairly closely with the machinability (applied to plain carbon steels only). The power values required to remove one cu. in. per min. of each of the materials in the respective tests are also given. See Metals & Alloys, Jan. 1930, Vol. 1, page 344 under the "Machinability of Metal." WHK

Non-Destructive Testing. Elmer Sperry. *Transactions American Society for Steel Treating*, Nov. 1929, Vol. 16, pages 771–798.

Paper presented before the Eleventh Annual Convention, American Society for Steel Treating, September 1929. Includes discussion. When direct current of high amperage (from 2000 to 4000 amp. in the case of steel rails) is passed through the specimen any minute crack or inclusion causes a deviation in the axis of current flow. This deviation is detected and amplified to a value suitable for operating, indicating and recording equipment. Most of the article is given over to a description of the application of this method to the detection of transverse fissures in rails in actual service. The applications to other forms such as rails in the mill, bars, tubes, axles, boiler plate and welded joints are also discussed. WHK

"Creep Limit" Alters Technique in Design of Large Tanks. Joseph Kaye Wood. *Chemical & Metallurgical Engineering*, Oct. 1929, Vol. 36, pages 610–613.

For determining stresses in oil tanks for high temperature and pressure author proposes the formula $S_w = e/100f$ C.L. in which S_w is the safe working stress, C.L. is the creep limit of the metal in lb./in.^{2} at service temperature, e, the welding efficiency taken at 90% and f, the factor of safety taken at 1.5. Discusses principles upon which it is based and compares it with other methods of design. MS

ELECTRO-CHEMISTRY

Electroplating

Determination of Sulfate in Chromium Plating Baths. H. H. Willard Richard Schneidewind. *Metal Cleaning & Finishing*, Dec. 1929, Vol. 1, pages 683–686.

Paper before American Electrochemical Society, Sept. 21. See Metals & Alloys, Jan. 1930, Vol. 1, page 342. MS

Scientific Plating Control: A New Method of Controlling the Amount of Metal Deposited from Electroplating Baths. L C. Turnock. *Metal Industry*, Oct. 1929, New York, Vol. 27, pages 478–482.

Ampere-hour meters equipped with signal contacts permit a given amount of power to be supplied to the plating bath. Baths must be maintained by analysis so as to insure a constant efficiency factor. Cost savings data are given for an acid copper installation equipped with this control system and used for plating radiator shells.—*Abstract Bulletin Kodak Research Laboratories.*

Wanted—Satisfactory Tests for Cadmium Plating. Karl A. Eckhardt. *American Machinist*, Dec. 19, 1929, Vol. 71, pages 995–997.

Gives the results of 5 tests on cadmium plated bolts. The tests made were: 1. Atmospheric; 2. Salt (NaCl) spray; 3. $NH_4OH + NaCl$ spray; 4. NH_4NO_3 (normal) spray; 5. $SbCl_3 + HCl$ spray. These tests show practically no correlation. No test, for cadmium plating, has been developed so far which may be considered satisfactory. RHP

Recent Progress in Electro-Deposition. R. S. Hutton. *Electrical Review*, Jan. 10, 1930, Vol. 106, page 93.

Extract from presidential address before Electroplaters' & Depositors' Technical Society. Points out how research in fields indirectly concerned with electroplating has benefited that industry and makes a plea for definite cooperative industrial research. MS

Commercial Chromium Plating. R. Schneidewind. *Circular Series* No. 3, *Department of Engineering Research*, University of Michigan, Ann Arbor, Michigan, January 1930, 60 pages, price 50¢.

This circular, which tells both how and why, is written for the practical plater. It is the best job of putting scientific facts into easily understood English we have seen in a blue moon. The task of writing a practical manual is one that is seldom well accomplished by the scientist. This series is edited by J. R. Nelson, Professor of English. If the cooperation of the English Department will produce such a good product, we recommend that more scientists secure the help of experts in the writing of English. Lacking such aid, they might copy the style of this circular. But the diagrams, which bring out salient facts so clearly, can hardly be ascribed to the editor, so we imagine that the editor had a pretty good manuscript on which to work. There is no especial need to review the contents of the circular; it contains a summary of the outstanding facts in regard to chromium plating, with sufficient attention to the reasons why the facts are as they are to make it of as much use of the scientist as to the practical plater. One may have all the information in other publications, but even so, anyone interested in chromium plating will find the circular worth its price. HWG

Electrolytic Deposition of Molybdenum at a Mercury Cathode. J. L. Merrill & A. S. Russell. *Journal Chemical Society*, London, Oct. 1929, pages 2389–2393.

For the electrolytic deposition of molybdenum the most suitable cathode is mercury. Sulphuric acid is more effective than hydrochloric acid, the optimum concentration of the former being 1.2 –1.4 N, more than twice that for chromium under corresponding conditions. The best current densities are 0.6 to 1.0 amp. per cm.^{2}, the time for the deposition of 0.1 gm. of molybdenum then being about 50 minutes. This time is little affected either by altering the temperature of the electrolyte, or by rotating the anode. It has been found that acidity and not current density is the important factor in deciding whether or not cathodic deposition of the molybdenum will take place. The color changes which take place during electrolysis are discussed.

Electrolytic Deposition of Tungsten at a Mercury Cathode. K. S. Jackson, A. S. Russell & J. L. Merrill. *Journal Chemical Society*, London, Oct. 1929, pages 2394–2398.

The statement by Féreé that tungsten may be deposited electrolytically at a mercury cathode from a solution of the trioxide or sodium tungstate in hydrofluoric acid is confirmed. The most favorable conditions for the deposition are: a temperature of 95° C.; an acid concentration of 4.6 N, and a range of current densities of 0.65–1.0 amp. per cm.^{2} A second acid, such as hydrochloric or sulphuric acid, must not be present.

Investigation of Anodes for Production of Electrolytic Zinc. H. R. Hanley, C. Y. Clayton & D. F. Nalsh. *Technical Publication* No. 321, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 8 pages.

Twenty-eight lead base alloys were investigated. Calcium in lead produced the greatest decrease in anode potential, but the passivity of this alloy was not equal to a lead-silver alloy. The addition of both calcium and silver resulted in an alloy with a low anode potential that was passive. JLG

Electrodeposition of Cadmium. Charles H. Proctor. *Metal Cleaning and Finishing*, Dec. 1929, Vol. 1, pages 669–672, 686.

The following solution gives good results in still or automatic conveyor plating: 1 gal. H_2O, 8 oz. NaCn (96–98%), 4 oz. CdO (86%), 2 oz. KOH (76%), and $^1/_{50}$ oz. 1 min. Postum as colloidal agent. For barrel plating the bath consists of 1 gal. H_2O, 10 oz. NaCN, 4 oz. CdO, 2 oz. KOH, and $^1/_{32}$ oz. Postum. Anodes are 99% Cd and 1½ Hg and ratio of anode to cathode area is 2 or 3 to 1. Temperature used is 80° F. The cathode current density in barrel plating is 15–20 amp./ft.^{2} and in the other methods it may be 25–30 amp./ft.^{2}. The voltage in barrel plating is 6–10 volts, while in still and conveyor plating it is 4–5 volts. After plating the usual procedure is followed. Before plating, gray or malleable iron is pickled in hot HF solution, washed, put in an alkaline solution, washed, and sand blasted. Sheet steel articles are cleaned in an alkaline solution, washed, given an acid dip, and washed. Most efficient rapid test consists in immersing specimen for 40 sec. in a boiling solution of 140 cc. H_2O_2 (3%), 19.1 cc. $HC_2H_3O_2$, and H_2O to make 1l. If deposit withstands this test, it will meet any normal specification against atmospheric corrosion. MS

Plating of Iron Floor Lamps. Meyer Roter. *Metal Cleaning & Finishing*, Nov. 1929, Vol. 1, pages 597–598, 606.

Outlines faulty plating procedure. In plating gray cast iron floor lamps author first cleans with a strong washing solution or an electrolytic cleaner. The work is then cyanided, rinsed and nickel-plated for 20–30 min. at $1^1/_2$ volts. Solution is slightly alkaline and consists of 1 gal. H_2O, 10 oz. $NiSO_4$ 2 oz. $NiCl_2$, 2 oz. H_3BO_3, 1 oz. NH_4Cl, and 1 oz. $MgSO_4$. After nickeling, the work is brass-plated for 40–60 min. at not more than 2 volts. The solution contains 1 gal. H_2O, $4^1/_2$ oz. NaCN, 3 oz. $Cu(CN)_2$, 1 oz. $Zn(CN)_2$, 1 oz. $NaHCO_3$, $^1/_2$ oz. NH_4Cl and $^1/_8$ oz. NaOH. MS

Barrel Nickel Plating. George Simmons. *Metal Cleaning & Finishing*, Dec. 1929, Vol. 1, pages 665–666.

Use of modern bakelite barrels can effect many savings, e.g., the elimination of all racking problems. The work comes direct from the barrel having a brilliant surface. A 40% HCl dip before the cold water rinse after plating prevents stains. The barrel should be completely immersed in the solution at all times during the loading and plating processes. MS

Chromium Plated Ball Mill Chips Under Impact. John Gross & S. R. Zimmerly. *Chemical & Metallurgical Engineering*, Oct. 1929, Vol. 36, page 617.

Note regarding the chipping off of 25% of the Cr plate on the inside of a 12 in. ball-mill, after it was run 20 min. with 140 lb. of $^{1}/_{2}$–$1^{1}/_{2}$ in. steel balls and 16 lb. of coarse quartz. Surface resisted the abrasive action of the quartz. MS

METALLIC COATINGS OTHER THAN ELECTROPLATING

Calorizing Steel to Prevent Oxidation. B. J. Sayles. *Machinery*, Nov. 1929, Vol. 36, pages 226–228; *Iron Age*, Dec. 5, 1929, Vol. 124, pages 1510-1512.

See Metals & Alloys, Feb. 1930, Vol. 1, page 384. RHP & VSP

Metallization. *Journal Society of Chemical Industry.* Nov. 1, 1929, Vol. 48, page 1069.

The process of metallization consists in melting a metal wire in the flame of a special oxy-acetylene or oxy-gas burner, the molten metal being atomized and forced at a velocity of some 3000 feet per second against the object which is being coated. Metallization gives pleasing matte coats of 0.001″ thickness upward. Not only metals, but wood, paper, cloth and even celluloid can be metallized, the surface of the object being but slightly heated. The coating is extremely adherent, and cannot be separated from its support either by hammering or bending.

Pickling Principles in Galvanizing. Wallace G. Imhoff. *Iron Age*, Oct. 10, 1929, pages 957–959.

Tests conducted on 5 batches showed that the longer the pickling time, the heavier the zinc coating deposited. VSP

Use of Electricity in Galvanising. R. M. Cherry. *Iron Age*, Aug. 15, 1929, Vol. 124, page 404; *Iron & Steel Engineer*, March 1930, Vol. 7, pages 129-131; *Iron & Coal Trades Review*, Vol. 119, Nov. 1, 1929, page 676.

Electric heat has been successfully used for hot galvanizing, wire, structural-steel shapes, castings and sheet-metal parts. Fuel fired tanks are heated in spots and the temperature is hard to control. Electric heating is uniform and may be automatically controlled by a thermocouple inside the tank. This permits better work at lower cost. A chart gives the solubilities at various temperatures within the usual galvanizing range. RHP & WHB & VSP

The Spraying of Metals. *Iron & Coal Trades Review*, Nov. 1, 1929, Vol. 119, page 705.

Any metal or alloy in wire form is automatically fed into the pistol used for spraying. In the pistol the metal makes contact with an oxy-acetylene flame which melts the wire, which is then blown against the surface to be coated, by compressed air at a velocity of about 3000 ft./sec. It is claimed that such a coating properly applied cannot be removed by either bending or hammering.

Rotary Retort Furnaces Used in Production of Calorized Steel. B. J. Sayles. *Fuels & Furnaces*, Dec. 1929, Vol. 7, pages 1917–1919.

Calorizing consists in the formation of an aluminum alloy on the surface of another metal, usually mild steel. In applying the process to seamless steel tubes, they are heated with aluminum compound in a hermetically sealed retort, a hydrogen atmosphere being maintained. The retort is revolved in a gas fired furnace. Operating temperature is 1740° F. For smaller work of irregular shape, dip calorizing is used, the essential unit being a tank set in an under-fired furnace. Calorized steel resists oxidation up to temperatures of 1650° F. and corrosion by gaseous sulphur products. MS

Copperizing Iron and Steel Surfaces. Charles H. Proctor. *Metal Cleaning & Finishing*, Nov. 1929, Vol. 1, pages 589–590.

Before depositing Cu by immersion, iron or steel surfaces should be cleaned by placing in bath of 4 oz. KOH and 2 oz. Na_3PO_4 per gal. of water at 200° F. for 5 min. It is then dipped in a solution of 1 gal. HCl per gal. of water for 10–30 sec. Solutions for depositing Cu may consist of 1 gal. water, 8 fluid oz. H_2SO_4 and 4 oz. dry $CuCO_3$, or 1 gal. water, $1^{1}/_{2}$ oz. H_2SO_4 (60°) and 1 oz. $CuSO_4$. The articles are immersed in either of these solutions until a uniform, clean Cu deposit is obtained. They are washed in cold water, followed by a cold soap solution, then in boiling water, and dried. MS

INDUSTRIAL USES AND APPLICATIONS

Armor Plate. The Possibility of Utilizing Low Carbon Industrial Steels. Roy E. Paine. *Army Ordnance*, Jan.–Feb. 1930, pages 239–247.

Bibliography of 40 references. The author investigates the possible use of heat treated low carbon open hearth steel for armor plate, but decides that its use to resist the direct fire of rifles and machine guns at close range is questionable, but believes that it can be applied in many cases where the material is not subjected to close range rifle fire.

High Quality Steel Utilized in Airplane Engines. H R. Simonds. *Iron Trade Review*, Dec. 5, 1929, Vol. 85, pages 1437–1441.

Steel and duralumin are used for engine parts. The steels are nearly all standard automotive steels. The chief difference in their application to aircraft construction is careful selection to give properties desired and full testing to insure uniformity. If they are not up to aircraft standard, they can be used in most cases for automotive work. As far as possible all important parts are forgings. Nearly all parts are heat treated to relieve internal strain and to produce the best grain structure, although many have ample strength and hardness without heat treatment. Tabulates the chemical composition and physical properties of the steels used. MS

Aluminum in Heavy Machinery. *American Machinist*, Dec. 12, 1929, Vol. 71, pages 959–960.

Due to rapid changes in industry there is an increased demand for machinery of reduced weight. Aluminum and aluminum alloys are making this possible. One manufacturer increased his consumption of aluminum and its alloys from 1000 lbs. in 1926 to 18,000 lbs. in 1928. RHP

Riveted Design Applied in Welded Pipe Line Construction. Russell C. Beam. *Pure Iron Era*, Fourth Issue, 1929, page 21.

The Department of Water Supply of Detroit is the first municipal department in the world to take advantage of the larger carrying capacity of welded pipe. Description is given of installation of this pipe in 40 ft. lengths MLM

Steel Castings for Dredger Work. W. Longden *Edgar Allen News*, Dec. 1929, Vol. 8, pages 512–517.

Typical examples of steel castings for dredging purposes are discussed and illustrated. MLM

The Possible Use of Beryllium in Aircraft Construction. H. W. Gillett. *Metal Industry*, New York, Nov. 1929, page 512.

Abstract of paper presented at the American Electrochemical Society meeting, Sept. 1929. See Metals & Alloys, Feb. 1930, page 385. VSP

New Fields for Alloy Steels Opened by More Exacting Demands. C. E. MacQuigg. *Iron Trade Review*, Dec. 19, 1929, Vol. 85, pages 1559–1561.

From paper before New York Section of the American Institute of Mining and Metallurgical Engineers. Alloy steels are being applied to meet the need for increased physical properties. Production has expanded until tonnage in 1928 amounted to 3,214,909 tons. Steel with 0.61% Cr and 0.79%C and 3.5% Ni steel have been used in bridges. For rails, 1.50% Mn steel with 0.55% C, and 3% Cr steel are finding application. Steels containing Al, Cr, Mo and V, are employed in aeronautics. Cutting tools consist of plain carbon and high speed steels and stellite. Tungsten carbide is being introduced for use in this field. MS

Selection of Case Hardening Steels for Highly Stressed Gears. H. W. McQuaid & O. W. McMullan. *Transactions American Society for Steel Treating*, Dec. 1929, Vol. 16, pages 860–892.

Paper presented before the Eleventh Annual Convention, American Society for Steel Treating, September, 1929. Includes discussion. Low carbon case-hardened stock has practically supplanted high carbon oil treated stock for automotive gears. The most widely used steels are S.A.E. 2315, 4615, 6115 and, for particularly severe service, S.A.E. 2512. The operations of forging, normalizing, carburizing, and heat treating are briefly discussed. Upset bar stock is far superior to flat stock for forging blanks. Normalizing should be so conducted as to produce a coarse grained pearlitic structure of a Brinell range of 156 to 179 for best machining properties. Carburizing compounds may be selected on a cost basis since actual carburizing results differ but little. Best practice is to produce a case of 0.030″ to 0.050″ with as little free cementite as possible. Most common heat treating practice is to cool in the pot and to reheat for quenching, although sometimes excellent results are obtained by quenching directly from the pot. Quenching should be done with oil in a well-designed fixture to reduce the warpage loss. Grain size is an important factor in selecting the proper procedure for both carburizing and heat treating. The second part of the paper gives the results of the experimental work done. Surface hardness tests, depth hardness curves, transverse loading of bars, notched and unnotched impact results, and dimension changes on bars and test rings are recorded. S. A. E. 4615 gives the highest surface hardness, and shows the most resistance to notch propagation, while S.A.E. 2512 has the best static load carrying capacity. Data are also given upon the newer steels for gear application, particularly of the Mn and Mn-Mo type. WHK

HEAT TREATMENT

Heat Treatment of Cast Iron and Malleable Iron. H. Bornstein. *Fuels & Furnaces*, Sept. 1929, Vol. 7, pages 1377–1383.

Gray cast-iron is heat treated in three ways: (1) heating to not over 1000° F. to relieve internal strains, and cooling in the furnace or in air; (2) heating above the critical to relieve strains and increase machinability, with cooling in the furnace or in air; (3) heating above the critical followed by an oil or water quench to increase hardness, which may or may not be followed by a draw. From malleable iron, a white cast-iron is produced first in either an air furnace or a cupola. The heat treatment consists in (1) bringing the castings up to the required temperature as soon as possible, (2) then holding at a temperature high enough to speed up graphitization without going so high as to obtain undesirable graphite form, and (3) then cooling slowly through the critical range to graphitize balance of the combined carbon. MS

Properties of Steels Tested

Size	Chemical Composition—Percent				Quench		Physical Properties				Reduction Area	Ballastic Properties Penetration Effected at			
												20 Yards		100 Yards	
Thickness Inch	C	Mn	S	P	° F.	Time Min.	Brinell Hardness	Ultimate Strength Lbs. per sq. inch	Elastic Limit Lbs. per sq. inch	Elongation Percent in 2 ins.	Percent	Service	A. P.	Service	A. P.
$^{1}/_{4}$	0.22	0.61	0.077	0.018	As received		163 477	77,300	56,720	15.6	27.0	....	....	Yes	....
$^{1}/_{4}$	0.22	0.61	0.077	0.018	1550	30	555 340	149,640	...	Broke Outside	14.0	....	....	Yes	....
$^{5}/_{16}$	0.21	0.59	0.055	0.011	As received	...	163 477	72,640	51,800	34.3	51.0	....	....	Yes	....
$^{5}/_{16}$	0.21	0.59	0.055	0.011	1550	30	444 364	124,330	...	6.2	10.0	....	....	Yes	....
$^{3}/_{8}$	0.18	0.57	0.068	0.017	As received	...	149 387	66,800	46,090	42.1	44.8	....	....	Yes	....
$^{3}/_{8}$	0.18	0.57	0.068	0.017	1600	40	228 217	104,770	...	18.7	38.0	....	Yes	Yes	....
$^{1}/_{2}$	0.22	0.59	0.051	0.012	As received	...	170 460	72,200	48,000	40.6	46.0	....	Yes	No	Yes
$^{1}/_{2}$	0.22	0.59	0.051	0.012	1650	40	387 387	104,320	...	17.2	28.0	No	Yes	No	No
$^{5}/_{8}$	0.24	0.75	....	....	As received	...	170 228	76,200	...	36.7	48.8	No	Yes		Yes
$^{5}/_{8}$	0.24	0.75	....	....	1600	40	302 269	141,900	...	7.8	8.4	No	No	No	No
Well Casing $^{3}/_{8}$	0.37	0.85	0.029	0.016	1450	30	515 340 415		Not available				Yes	No	Yes

Parts for Universal Joint Assemblies Require Careful Heat Treating. H. R. Simonds. *Iron Trade Review*, Dec. 19, 1929, Vol. 85, pages 1555–1558.

Journal piece, forged from S. A. E. steel, is heated at 1550° F. in a screw type furnace, quenched in water at 90° F. and drawn at 1160° F. Forged stub shafts are normalized before first machining operation. They are heated at 1510° F. in special type of furnace designed to permit fractional quenching, and quenched at 80° F. Some steel parts of 0.10–0.20% C. are carburized before heat treatment. The desired case of 0.04–0.06″ is produced in 5 hours at 1430–1500° F. in rotating cylinder type furnace. They are heat treated in an automatic electric furnace at 1460–1500° F., water quenched at 116° F. and drawn at 330° F. Use welded steel tubing in the assembly. MS

Heat Treatment of Tool Steel. Dempster Smith. *Iron & Coal Trade Review*, Dec. 13, 1929, Vol. 119, page 905.

Abstract of a paper before the North-East Coast Institution of Engineers & Shipbuilders, Newcastle-upon-Tyne, Dec. 6, 1929. All references relate to ordinary high-speed steel of the following composition; carbon 0.65, tungsten 13.08, chromium 2.97, vanadium 0.52%. The usual 2 stage heating in 2 furnaces, one at 800° C. and the other at 1350° C. is unsatisfactory as a band of blisters which appear in a band just back of the edge should be uniform over the tool. Secondary heat-treatment to a hardened steel to produce maximum hardness should be at, but not above 580° C. for about an hour. RHP

Electric Heat in Treatment of Axes. Wirt S. Scott. *Heat Treating & Forging*, Nov. 1929, Vol. 15, pages 1483–1488. Condensed. *Fuels & Furnaces*, Nov. 1929, Vol. 7, pages 1701–1704.

Paper read at Third National Fuels Meeting of the American Society of Mechanical Engineers, Oct. 7–10. See abstract "Tempering and Coloring Axes," Metals & Alloys, March 1929, page 428. MS

Hardening

Surface Hardening. *Automobile Engineer*, Oct. 1929, Vol 19, pages 377–378.

A process for surface hardening gears is now being worked out which provides means for mechanically controlling the movement and heat of the flame used in the hardening process. The water jet used to quench the steel is also mechanically controlled. This method is to replace the manual process now being used which is similar, but which is entirely dependent on the skill of the operator. This process hardens only the wearing surface of the gear leaving the other part unhardened thereby increasing the strength of the gear. RHP

Hardening Thin Gauges. Charles Kugler. *Modern Machine Shop*, Feb. 1930, Vol. 2, page 64.

A simple method for keeping thin gages straight during hardening is described. MLM

Case Hardening and Nitrogen Hardening

Aluminum Hardening and Surfacing Method. *Brass World*, Sept. 1929, Vol. 25, page 221.

A method has been developed for hardening and surfacing aluminum and increasing its corrosion resistance. Aluminum trays are prevented from smudging the scleroscopic hardness tests showing an increase of 100%. The process is applied by immersion and may be compared to the cyanide hardening of steel. *Abstract Bulletin Kodak Research Laboratories.*

Exceptionally Large Nitriding Furnace Installation. *Fuels & Furnaces*, Dec. 1929, Vol. 7, pages 1907–1910, 1934.

There has been recently placed in operation a 600-kw. car-type furnace, a 60-kw. box-type furnace, and a 10.5-kw. cylindrical-type furnace, all electrically heated. The largest handles parts up to 22 ft. in length. Nitriding is applied after fabrication. The steel is heat treated in the usual manner, except that quenching is done at 1700–1750° F. in water with 0.30–0.40% C steel in sections 1″ or larger. Oil may be used for smaller sections. For 0.20–0.23% C steel, a water quench is used. For best machining and drawing a temperature of 1350–1400° F. is used. Nitriding box is made of welded Enduro Nirosta steel, and has a lid which fits into a rose metal seal. When the rose metal melts, the lid sinks thus sealing the box. Flow of NH_3 is regulated until a dissociation of 25–30% is obtained. Temperature maintained in the box is 950–975° F. Time for nitriding varies from 10–90 hrs. depending on depth of case desired. MS

Nitride and Cyanide Hardening of Vacuum Cleaner Parts. R. G. Roshong. *Fuels & Furnaces*, Sept. 1929, Vol. 7, pages 1393–1396, 1408.

Small parts are made from S.A.E. 1015 steel, hardened by cyaniding at 1600° F. and quenched in oil. Furnaces are of the electrically heated, ribbon resistor type. Pots are of pressed steel with an exterior coat of high Ni heat-resisting alloy. Beater bars are made from cold-rolled, low-carbon strip steel drawn to 1350° F. in an atmosphere of city gas, following the last cold pass. They are nitrided for 12 hrs. at 950–980° F. in a box-type furnace, electrically heated with ribbon resistors. The flow of ammonia is regulated until 15–30% is dissociated. If the dissociation is much above 30%, soft spots may occur and the surface is apt to crumble easily. This is probably due to the excessive amount of active hydrogen formed. Thorough distribution of the gases is essential to good nitriding. MS

Quenching

Hot Solutions for the Quenching of Steels. H. J. French & T. E. Hamill. *Transactions American Society for Steel Treating*, Vol. 16, Nov. 1929, pages 711–739; *Bureau Standards Journal of Research*, Sept. 1929, Vol. 3, pages 399–418; *Fuels & Furnaces*, Oct. 1929, Vol. 7, pages 1543–1545; *American Machinist*, Oct. 12, 1929, pages 413–414.

From paper before American Society for Steel Treating, Sept. 9–13. See Metals & Alloys, Jan. 1930, Vol. 1, page 344. MS & WHK

Dilatation of Steel During Quenching. G. M. Eaton. *Transactions American Society for Steel Treating*, Dec. 1929, Vol. 16, pages 819–859.

Paper presented before the Eleventh Annual Convention, American Society for Steel Treating, September, 1929. Includes discussion. Transient plastic flow during quenching causes residual internal stresses in steel. Martensitic dilatation aggravates this condition, particularly in alloy steels. The irregularities of an unmachined surface tend to produce centers of incipient failure which, even if submicroscopic, cannot be healed by subsequent tempering. Since the test pieces ordinarily used in tension and torsion as well as in fatigue tests are small and well machined the usefulness of the results obtained as applied to large unmachined forgings is questionable. New methods of testing, using larger and unmachined test specimens are advocated. Steel-makers are urged to produce ingots and forgings of better surface conditions, particularly in alloy steels. The apparatus used in the study of quenching conditions is described. In the discussion, Freeman points that the dilatation designated "martensitic" is actually that due to the gamma-alpha transformation, and, therefore, takes place whether martensite is formed or not. WHK

Annealing

Annealing Malleable Iron. Short Cycle Method. *Foundry Trade Journal*, Dec. 26, 1929, page 462; Jan. 2, 1930, page 141; *Iron & Coal Trades Review*, Dec. 1929, Vol. 119, page 907.

Brief abstract taken from the Iron Trade Review. Discusses a method whereby the annealing process is shortened to 28 or 30 hours. A short account of the process is given. See also Metals & Alloys, Nov. 1929, Vol. 1, pages 233–234; March 1930, Vol. 1, page 429. VSP & RHP

JOINING OF METALS AND ALLOYS

Welding and Cutting

Sees Expanding Applications in Welding with Oxyacetylene. *Iron Trade Review*, Nov. 21, Vol. 85, pages 1312–1313, 1315, 1317.

Report of thirtieth annual convention of the International Acetylene Association held in Chicago, Nov. 13–15, with abstracts of some of the papers presented. These deal with structural steel and aircraft welding. An abstract of the report of the Oxy-acetylene Committee is also given. See Metals & Alloys, March 1930, Vol. 1, page 429. Report of Oxy-Acetylene Committee of International Acetylene Association. MS

Thermit Welding in Steel Mills. J. H. Deppeler. *Iron Trade Review*, Oct. 31, 1929, Vol. 85, pages 1096–1097, 1150.

From paper presented before American Iron & Steel Institute, Oct. 1929. See Metals & Alloys, Feb. 1930, Vol. 1, page 387.

Training Course for Aircraft Welders. *Oxy-Acetylene Tips*, Feb. 1930, Vol. 8, pages 157–163.

The article outlines lectures, demonstrations and shop work in training welders for the aircraft industry. MLM

Tight Joints in Commercial Copper. *Oxy-Acetylene Tips*, Feb. 1930, Vol. 8, page 147.

Bronze welding of copper' hot water heating coils produces best results. MLM

Welding Locomotive Parts with the Electric Arc. James M. Vossler. *Modern Machine Shop*, Feb. 1930, Vol. 2, pages 11–20, 38.

Electrical arc is most economical for repairing locomotive frames. Causes of failures in frames are given and method of repairing different breaks discussed and illustrated. Too much care cannot be exercised in the selection of proper welding rod. MLM

Using the Electric Arc to Weld Cast Iron. A. R. Allard. *Iron Trade Review*, Oct. 17, 1929, Vol. 85, pages 969–972; Nov. 14, 1929, pages 1250–1252.

Cast-iron is difficult to weld even under most favorable conditions because of impurities producing brittleness, lack of ductility, low tensile strength and effect of localized heat. Satisfactory repairs of cast-iron parts may be made by proper preparation and operations. Carbon-arc process usually requires preheating unless part is small. It is not necessary to preheat casting with metallic-arc process as the heat of the arc is more localized. The latter process is used more extensively. Chilled cast-iron is formed in the carbon-arc process. In the metallic-arc process, using steel electrodes, the closer the C approaches the combined form the better will be the union of the metals, and the closer it approaches the graphitic form the poorer the union. The difference in contraction between the molten added layer and the cast-iron often causes trouble. Outlines correct procedure for metallic arc welding. Welds are difficult to machine and are worked usually by grinding. MS

Welding in Europe and Great Britain. J. W. Urquhart. *Heat Treating & Forging*, Nov. 1929, Vol. 15, pages 1451–1455, 1459.

Although welded unfired pressure vessels have been freely insurable in Europe, such has not been the case in England. Only recently one British concern has granted insurance to such vessels but excludes all welded fired vessels. The companies apparently seek a weld that is of the same composition, tensile strength and ductility as the steel which is joined. To obtain effective and reliable joints, the use of welding rods of the correct composition is very important. Other factors are: proper heat, time and method. Insurance people point to the possibility of brittleness in the filling material. Preheating the work has been found advantageous in preventing this defect. Objection is also made to the use of reinforcing straps, on the ground that satisfactory examination of the weld is prevented. In some European countries, the straps are fillet-welded to the plate, and are carried across the butt weld, at right angles, thus overcoming this objection. Electrical machinery is now being fabricated by arc welding in England and Continental countries. MS

Gas and Electric Welding Methods Abroad. R. W. Miller. *Heat Treating & Forging*, Dec. 1929, Vol. 15, pages 1589–1593.

In gas welding, the deposited metal is hammered while red hot to improve its condition. Careful annealing improves the microstructure. Boilers, high pressure pipe lines, etc., are tested at pressures 50–100% greater than the working pressure. A variety of tests, such as tensile, torsion, cold bend and hot bend are made on test pieces or articles chosen at random. Etching tests are very useful for investigating welds. Some comparative tests indicate that if it is desired to have the finished work as uniform throughout as possible, gas welding is to be preferred. Electric welding should be used if high elastic limit or high tensile strength is desired. MS

Welding is Aid to Progress in Auto Body Fabrication. Joseph W. Meadowcraft. *Iron Trade Review*, Nov. 7, 1929, Vol. 85, pages 1167–1169, 1174; *Metal Stampings*, Nov. 1929, Vol. 2, pages 895–899.

From paper presented at World Engineering Congress in Tokyo, Oct. 1929. Improved welding methods have facilitated use of lighter gage sheets, increased production, simplified operations, and reduced costs. Proper selection of materials and a design which is simple and readily adaptable to welding are important factors. All usual methods of welding except the thermit weld are used, but spot and flash welding are the 2 types most readily adaptable. All steel bodies are completely welded. MS

WORKING OF METALS AND ALLOYS

Melting and Refining

Steel Melting Practice for Large Ingots and High Grade Castings. W. H. White. *Fuels & Furnaces*, Sept. 1929, Vol. 7, pages 1389–1392.

Condition, color, and analyses of slag give an indication of quality of steel. In acid practice, when slag is green and Fe and Mn are under 35%, the steel will have superior physical characteristics over that when slag is black with high Mn and Fe. In basic electric practice, the white disintegrating, carbide melting slag with Fe and Mn under 2.50 gave superior physical characteristics. Ingot and casting heats should be poured as cold as good casting will allow. Critical stages of a heat are when it is all melted and when it is ready for its finals. Refining operation should take about 25% of the complete heat time. MS

Basic Open-Hearth Slags. E. J. Janitzky. *Iron & Coal Trades Review*, Nov. 22, 1929, Vol. 119, page 788; *Blast Furance & Steel Plant*, Nov. 1929, Vol. 17, pages 1642–1647; *Fuels & Furnaces*, Dec. 1929, Vol. 7, pages 1867–1870. *Iron Age*, Vol. 124, 1929, pages 1235–1238; *Yearbook American Iron & Steel Institute*, 1929, pages 417–436.

Abstract of a paper entitled, "A Study of Basic Open-Hearth Slag by Solidification Tests" read before the American Iron & Steel Institute, Oct. 1929. See Metals & Alloys, Feb. 1930, Vol. 1, page 387. RHP & MS & VSP

Zinc Chloride Fluxed Aluminum. James Silberstein. *Foundry*, Dec. 15, 1929, Vol. 57, page 1042.

Discusses the removal of foreign substances from the molten metal which partly float to the surface, while some of it is imbedded in the metal. Zinc chloride is used as a flux for cleaning aluminum alloys. The action of zinc is two-fold: It reacts with the aluminum and the metal is freed from adhering dross and dirt. Also it forms gas which agitates the metal and carries the foreign material to the surface. Recently sodium silico-fluoride has been used. It is cheaper than zinc chloride but less energetic. SP

High Quality Steel is Produced in Electric Furnaces. Henry D. Phillips. *Foundry*, Dec. 1, 1929, pages 997–998.

Describes method employed to produce plain carbon steel in the acid electric furnace. Acid steel properly made is of exceptionally high quality. Test bars normally annealed passed all specifications. Gives general method used in the manipulation of heats, with special emphasis on the deoxidation of the slag and the removal of practically all of the ferrous oxide from the slag. VSP

A New Method for Determining Iron Oxide in Liquid Steel. C. H. Herty, Jr., J. M. Gaines, Jr., H. Freeman & M. W. Lightner. *Technical Publication* No. 311, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 13 pages.

The sample is taken from the furnace with a test spoon, aluminum added to the metal in the spoon and a small ingot cast, the Al_2O_3 content of which is determined. From the alumina content the FeO content of the bath is calculated. Results are given showing the change in FeO and C during the production of an acid and a basic open-hearth heat. JLG

Melting Bearing Bronze in Open-flame Furnaces. Ernest R. Darby. *Technical Publication* No. 302, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 7 pages.

The effects of using an oxidizing and a reducing atmosphere are discussed. In many instances best results are obtained by melting down in a reducing atmosphere and finishing with an oxidizing atmosphere. JLG

Rate of Carbon Elimination and Degree of Oxidation of Metal Bath in Basic Open-hearth Practice. II. Alexander L. Feild. *Technical Publication* No. 280, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 7 pages.

The nature of the equilibrium between carbon and FeO in a basic open-hearth furnace is reconsidered with the use of the equilibrium constant determined by Kinzel and Egan. Equations showing relationship between the carbon and FeO content during boiling and after cessation of the boil are given. The high FeO content in reference to the carbon content after the cessation of the carbon boil can be explained by increased CO pressures in the quiet bath. JLG

Production of Gray Iron from Steel Scrap in the Electric Furnace. T. F. Bailey. *Technical Publication* No. 296, *American Institute Metallurgical & Mining Engineers*, Feb. 1930, 17 pages; *Iron Age*, March 6, 1930, Vol. 125, pages 725–726.

The shaft of an electrode furnace was filled with coke in such a manner that the current flowed from the 3 electrodes to the top of the coke. Light steel scrap together with open-hearth slag and sand were charged on top of the coke. The steel scrap when melted flowed through the coke thereby absorbing carbon; manganese, sulphur and phosphorus were reduced from the slag and sand. Chemical, physical and microscopic examination of the resulting iron indicated that a gray iron equivalent to cupola iron could be produced in such a manner and cast directly from the furnace. JLG&VSP

Melting and Casting Some Gold Alloys. Edward A. Capillon. *Technical Publication* No. 282, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 20 pages.

For the smallest scrap losses the length of the ingot should be about 4 times its width. Gold alloys and silver alloys absorb gases, particularly oxygen, and in order to prevent porous ingots it is necessary to deoxidize before pouring. Zinc, phosphorus and calcium boride are good deoxidizers for gold-silver-copper alloys, and aluminum, magnesium and manganese are unsuitable. Sterling silver can be treated with a copper-phosphorus alloy. High casting temperatures for gold alloys did not decrease the workability of the ingot or the ductility of the finished sheet. The effect of impurities in gold alloys is discussed. JLG

Distribution of Lead Impurity in a Copper-refining Furnace Bath. J. Walter Scott & L. H. DeWald. *Technical Publication* No. 290, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 5 pages.

Analyses of samples taken from various portions of the metal in a 45-ton reverberatory furnace during the refining period indicated a rather uniform distribution of lead, but as oxidation progressed there was a slight tendency for the lead to concentrate toward the surface. JLG

The Physical Chemistry of Steel Making, Deoxidation of Steel with Aluminum. C. H. Herty, Jr., & J. M. Bryns. *Mining & Metallurgical Advisory Boards*, Pittsburgh, Cooperative Bulletin No. 46, *Mining & Metallurgical Investigations*, 1930, 45 pages, price $1.00, obtainable from J. D. Beatty, Carnegie Institute of Technology, Pittsburgh.

This records one phase of the extensive work on inclusions in steel carried on in cooperation of the Bureau of Mines, Carnegie Tech. and 43 firms in the steel industry. The experimental data discussed are not very extensive, but the steel industry should be grateful to Dr. Herty and his associates for not holding back data as they are secured, but instead, publishing frequent progress reports. A partial study of the FeO–Al_2O_3 system shows that at around 60% Al_2O_3 the slags are liquid below the melting point of iron and thus have some fluxing properties, though it would be difficult to control the aluminum addition so as to be certain of producing a fusible slag. In the experimental work to an ingot of one heat containing 0.05% C, 0.03% Mn, there was added 0.05% Al. The inclusions contained about 75% Al_2O_3, while to another containing 0.02% C, 0.08% Mn, a similar amount of aluminum was added, and the inclusions contained about 40% Al_2O_3. The segregation of the inclusions was studied, as was the forgeability of the ingots. Using the modified Ledebur method for determination of FeO, the relation between the metallic aluminum content and the unreduced FeO content of low carbon heats was studied, and the conclusion drawn that aluminum, weight for weight, leaves as much free FeO in the steel as silicon does, and is not a more powerful deoxidizer than silicon. It is, however, a more rapid deoxidizer, and since it does not diffuse rapidly through molten steel, its concentration is high in that part of the bath or ingot to which it is added, and high local deoxidization occurs. To this local action is ascribed the characteristic grouping of inclusions containing high Al_2O_3. An appendix gives thermodynamic calculations of the deoxidation constant on the free energy basis. No great claim for correctness is made for the calculations because of the assumptions involved. Analytical methods for determination of total aluminum in steel, as developed by the Bureau of Standards, are given in the appendix. The price of the bulletin is a bit staggering when it is considered that it represents work, much of which was done on Government funds. Were the bulletin published as a Government document, it would be priced at not over a quarter. HWG

Utilization of Secondary Metals in the Foundry. H. M. St. John. *Metal Industry*, New York, Nov. 1929, pages 513–515.

Discusses value of scrap metals in red brass foundry. See Metals & Alloys, Feb. 1930, page 388. VSP

Open-Hearth Control Equipment Affects Quality of Output. *Iron Trade Review*, Nov. 14, 1929, Vol. 85, pages 1246–1247, 1252.

Report of tenth semi-annual conference of the Open-hearth Committee, American Institute of Mining and Metallurgical Engineers held in Chicago, Nov. 5–6. MS

Beryllium—Its Extraction and its Alloys. *Heat Treating & Forging*, Nov. 1929, Vol. 15, pages 1460–1461.

Translated from *Zeitschrift für die gesamte Giessereipraxis*, Aug. 18, 1929. *Das Metal*, page 129. Although numerous investigators have worked on the preparation of Be, Stock and Goldschmidt are apparently the first to produce pure Be in compact form. Their process consists in the electrolytic treatment of a melt containing as an essential component an alkaline earth fluoride, preferably BaF_2. Be has a density of 1.84, m.p. of 1280° F., modulus of elasticity of 30,000 kg./mm.^{2} and Brinell hardness of 140. It is not ductile nor readily machinable and is very hard. MS

Casting and Solidification

Railroad Bronzes are Cast in Permanent Molds. Henri Marius. *Foundry*, Jan. 1, 1930, Vol. 58, pages 104–107.

Describes and illustrates method employed for permanent mold casting. Brass castings known as wearing metals are made in permanent molds. The special iron mold, the characteristic feature of which is the standard gate and riser combination. Another feature is that these castings are cast on end. Whenever they have flanges at the ends they are cast with the widest flange up. VSP

Steel Ingots. W. H. Hatfield. *Iron & Coal Trades Review*, Dec. 20, 1929, Vol. 119, page 952; *Iron Age*, Jan. 30, 1930, Vol. 125, page 368; *Rolling Mill Journal*, Feb. 1930, Vol. 4, pages 53–54.

Abstract of a paper before the South Wales Institute of Engineers, at Cardiff, Dec. 12, 1929. Steel contracts, on solidification, about 1.5% of its volume. Contraction takes place in both the liquid and the solid state. Due to these contractions, cavity or pipe is formed in the ingot. By use of a refractory-lined feeder head which keeps the top part of the ingot molten while the bottom portions are solidifying the whole cavity can be obtained in the feeder head. Heterogeneity is caused by differential freezing. The amount of heterogeneity is affected by the mass, type of ingot and the composition of the steel. To decrease heterogeneity: 1. The steel shoud be piping steel. 2. The mold should be wider at the top and should have a refractory-lined feeder head. 3. The steel should be cast as low as practicable. 4. Use correct size of nozzle for size of ingot and nature and temperature of the steel. 5. Deoxidize the steel before it leaves the furnace. 6. Sulphur and phorphorus content should be low. RHP & MS

Crystallization, Segregation Phenomena. Alex Hultgren. *Blast Furnace & Steel Plant*, Oct. 1929, Vol. 17, pages 1511–1516; *Engineering*, 1929, Vol. 128, pages 816–818; pages 851–852.

From paper before Iron & Steel Institute, Sept. 1929. See Metals & Alloys, Feb. 1930, Vol. 1, page 388. MS

Comparison of Copper Wire Bars Cast Vertically and Horizontally. J. Walter Scott & L. H. DeWald. *Technical Publication* No. 289. *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 11 pages.

The bars cast vertically were of the same dimensions as those cast horizontally, their sides were smooth, the density higher except near the top, and the wire made from them of a slightly higher conductivity. The vertically cast copper lends itself more readily to processing, although the top portion of the ingot is less satisfactory for the production of fine wire. JLG

Forging

Reduction from Ingot to Forging in Steel. Lawford H. Fry. *Heat Treating & Forging*, Oct. 1929, Vol. 15, pages 1299–1303; *Rolling Mill Journal*, Dec. 1929, Vol. 3, pages 523–525; *Canadian Chemistry & Metallurgy*, Nov. 1929, pages 306–312.

Paper before American Society for Testing Materials, June 24–28, 1929, entitled "The Effect of Reduction from Ingot to Forging in Steel Forging," See Metals & Alloys, Jan. 1930, Vol. 1, page 344. MS

Machining

Carboloy Tool Saves 148½ hours Grooving Chilled Iron Roll. *Carboloy*, Feb. 1930, Vol. 1, page 5.

The Carboloy tool was ground only once every 95 grooves, as compared with a high speed steel tool which was ground 3 times per groove in a lengthy machining operation in the scoring of a chilled iron cylinder. MLM

Saving 105 hours Machining a White Iron Calender Roll. *Carboloy*, Feb. 1930, Vol. 1, pages 18–19.

Carboloy tools completed a job of machining in 95 hours which would have taken high speed steel 200 hours, on material Rockwelling 0.47 on the C-scale. MLM

Carboloy Tools Increase Production 50% on Cast Steel and 25% on Phosphor Bronze. *Carboloy*, Jan. 1930, Vol 1, pages 6–7, 23.

Four interesting applications of Carboloy tools on cast steel and bronze are given and savings effected by such use are tabulated. MLM

Machining Brass Forgings at the Titan Metal Mfg. Co. *Carboloy*, Jan. 1930, Vol. 1, pages 20–21, 23.

Carboloy is successful in effecting a material economy in the machining of non-ferrous materials. MLM

Drawing and Stamping

Internal Stress and Season Cracking in Brass Tubes. D. K. Crampton. *Technical Publication* No. 297, *American Institute Mining & Metallurgical Engineers*, Feb. 1930. 18 pages.

The internal stresses and tendencies to season crack of brass tubing of varied composition and drawn in different manners was studied by means of circumferential stress measurements, mercurous nitrate tests, atmospheric exposures and "fire-cracking" tests. It was found that both the copper content and the internal stresses had a profound influence on the tendency to season crack. With proper drawing it is possible to produce brass tubing of any hardness that will not season crack. JLG

Pickling

Economical Operation of the Pickling Department. F. G. Jaeger. *Metal Cleaning & Finishing*, Nov. 1929, Vol. 1, pages 621–625; Dec. 1929, pages 675–768, 703–704.

Layout of pickling room should provide maximum convenience and continuity of flow of product. Floors should be sound, strong, level and smooth. Proper ventilation should be provided. Foundations of tanks should allow for adequate drainage. Wooden tanks have proved to be the most effective and economical containers of pickling liquors. The timbers should be sound and strong. It is important to have suitable tank fittings, such as bolts, tie rods, etc., to prevent leakage. The metal must be corrosion resistant, strong, of high yield point and endurance, free from metallic fatigue and components that will start corrosion by cementation and readily machinable. Discusses the various factors. MS

Cold Working

The Use of Cold-rolled Steel Strip Stock. R. H. Vie. *Machinery*, N. Y., Dec. 1929, Vol. 36, pages 303–304.

There are 5 grades of cold-rolled steel strip stock. A diagram is given which shows the angles through which each grade may be bent and the hardness rating of each by the Brinell, Erichsen and scleroscope scales. The hard is the best blanking material. The half hard is good for blanking and will take a sharp right angle bend in transverse direction to the grain. The medium soft will take a sharp right angle bend along the grain and a 180° bend when transverse. The dead soft will take a 180° fold either way. The special dead soft is used in deep drawing. Its drawing qualities are not improved by annealing. RHP

Cleaning

Preparations of Parts for Plating. John I. Harper. *Metal Cleaning & Finishing*, Nov. 1929, Vol. 1, pages 579–580.

Surface preparation prior to cleaning is one of the most important factors governing finished work. The cleaner best suited to the work should be used. If the work covers a wide variety, several kinds of cleaners should be kept on hand. Improper cleaning results in spoiled work, no matter how carefully plating operations are carried out. MS

Grinding

Use of Abrasives for Polishing Constantly Increasing. *Grits & Grinds*, Jan. 1930, page 12.

Al_2O_3 and Si carbide abrasives have largely replaced the natural abrasives in polishing operations on glass and metal. Numberless parts on autos, cutlery, metal trimmings, etc., are polished by Alundum. MLM

Grinding Carboloy Equipped Inserted-Blade Milling-Cutters. *Carboloy*, Jan. 1930, Vol. 1, pages 10–16, 19, 23.

Blades tipped with Carboloy, properly mounted in a cutter body and ground correctly permit the removal of metal at unusually high speeds thus increasing production and reducing manufacturing costs. Several illustrations and diagrams are given and proper procedure discussed. MLM

DEFECTS

Oxides in Brass. O. W. Ellis. *Technical Publication* No. 283, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 19 pages.

From a series of melts containing not less than 84% copper, 4 - 10% zinc, 2.5 - 6% tin, and 1 - 4% lead, made in a 42″ oil fired furnace, chill cast and sand cast specimens were obtained. The heats varied in regard to the charge and the flux used. There was no apparent correlation between composition and tensile strength. Oxide counts were made by determining the number of particles in a given area. The area of the particles was also determined and an estimate made of the total volume of oxides. The chill cast samples had a greater number of oxide particles but their size was less. The amount of oxides present depended chiefly on the character of the charge. JLG

Certain Types of Defects in Copper Wire Caused by Improper Dies and Drawing Practice. H. C. Jennison. *Technical Publication* No. 285, *American Institute Mining & Metallurgical Engineers*, Feb. 1930, 14 pages; *Rolling Mill Journal*, Vol. 4, Feb. 1930, pages 55-58.

Illustrations of 2 distinct types of defects occurring in copper wire are given, namely, "check-marks" and "cuppy wire." These defects are produced by incorrectly designed or incorrectly made dies, and a die that will produce satisfactory wire is described. Cuppy wire may also be produced with the best design of dies in a continuous machine when there is not sufficient slip. Wire bars meeting the A. S. T. M. specifications can be drawn successfully with the proper dies and a correctly adjusted machine. JLG + MS

A Study of Burning and Overheating of Steel—Part III. W. E. Jominy. *Transactions American Society for Steel Treating*, Dec. 1929, Vol. 16, pages 893–936.

Paper presented before the Eleventh Annual Convention, American Society for Steel Treating, September, 1929. Includes discussion. This paper gives the results of an extensive series of experiments on S. A. E. 1015, 1030, 1050, 1085, and 3145 to determine whether or not fairly long heating (as for forging) at temperatures just below the burning points would have a deleterious effect upon the structures and physical properties of these steels. Many numerical data are given, comprising tensile tests, hardness tests, impact tests, electrical conductivity tests, microscopic examinations, McQuaid-Ehn tests, macroscopic examinations and fracture examinations, made upon specimens of the above mentioned steels which were heated to near and within a range of 400° F. below the burning point followed by normalizing or by reheating and quenching and tempering. For comparison the same tests were made upon similar specimens not given the high temperature treatment. The results may be summarized in the following table which shows the temperatures which it is safe to attain with the respective steels without impairing their physical properties, provided that the steels are properly heat treated (or forged) afterward.

Steel	Max. Safe Temp. ° F.
S. A. E. 1015	2650
S. A. E. 1030	2600
S. A. E. 1050	2525
S. A. E. 1090	2375
S. A. E. 3145	2450

These values should not be relied upon if the furnace atmosphere is oxidizing, or if the period of heating is over 2 hours. In the discussion O. W. Ellis relates the phenomena observed by Jominy to the solidus of the iron–carbon system. WHK

Steel Failures in Aircraft. F. T. Sisco. *Transactions American Society for Steel Treating*, April 1929, Vol. XV, pages 589–629.

Cites case where a sharp-cornered burr on an improperly machined steel part in an adjustable blade duralumin airplane propeller was forced into the softer duralumin in assembly creating a notch in the duralumin that resulted in fatigue failure. "Most failures of aircraft engine parts take place by fatigue." "In the work done at Wright Field a mass of evidence has been accumulated that shows without doubt that non-metallic inclusions are responsible for, or at least accelerate, fatigue failure." Micrographs of failures with the path of the fatigue crack determined by inclusions are shown. Hair-line seams are discussed. The preponderance of evidence is that for a given stress the crank-shaft that contains large numbers of hair-line seams will fail when the shaft wholly free from them will not fail. Cracks resulting from faulty heat treatment, or from too small fillets which result in hardening cracks, are the source of some fatigue failures. Unsound areas in welds can be detected only by accident, that is, the unsound specimen being selected for a test to destruction. Seamless tubes are preferred over mill-welded tubes.—*From Abstracts by the A. S. T. M. Research Committee on Fatigue of Metals.*

CHEMICAL ANALYSIS

Determination of Traces of Iron by Photochemical and Colorimetric Methods. B. S. Sharma. *Journal Society of Chemical Industry*, Nov. 1, 1929, Vol. 48, page 336T.

A saturated solution of ammonium thiocyanate, to which has been added a trace of ferric or ferrous iron, develops a pink color proportional to the amount of iron present when it is exposed for 10 minutes to sunlight or the light of an iron arc. When the pink solution is placed in the dark the color fades, the time of fading being proportional to the amount of iron introduced. The time of fading was 15 minutes for 1.7762×10^{-11} gm. of ferrous iron and 150 minutes for 17.7617×10^{-11} gm.

HISTORICAL AND BIOGRAPHICAL

Famous Steel Men and Engineers. Sir William Siemens. *Edgar Allen News*, Feb. 1930, Vol. 8, pages 549–551.

First of a series of articles about men who revolutionized the steel industry. Sketch of the life of Sir William Siemens is given. MLM

The Status of the Steel Foundry in 1930. *Research Group News*, Jan. 1930, Vol. 6, pages 272–276.

A short history of the steel industry is given with special attention paid to the present status of the 4 processes, open-hearth, electric furnace, converter and crucible. MLM

Important Steps in the Advance of Copper Metallurgy. Eugene A. White. *Mining & Metallurgy*, Jan. 1930, Vol. 11, pages 56–57.

Report, by Chester F. Lee, of an address before the North Pacific section American Institute of Mining Engineers, Nov. 20, 1929. Gives a historical review of the various steps that have led up to the present high state of metallurgical technology of copper. VSP

Ancient Iron and the Modern Science of Metals. V. N. Krivobok. *Fuels & Furnaces*, Dec. 1929, Vol. 7, pages 1839–1842.

Examination of pieces of ancient iron and study of old manuscripts show that the ancients knew of the existence of "iron," "steel" and hard alloy "pig iron." Author's examination of several mediaeval pieces indicates that carburization and heat treatment were practiced in those days. Illustrates by means of photomicrographs the structure of steels and the changes caused by heat treatment, addition of alloying elements and nitriding. MS

ECONOMIC

Summarized Data of Lead Production. Lewis A. Smith, et al. *Economic Paper* No. 5, *United States Bureau of Mines*, 1929, 44 pages.

A single large table shows the production of lead by countries from 1801 – 1927, 1801 – 1820 by decades, 1821 – 1860 by 5 year periods, and annually from 1860 – 1927. Production in this period has amounted to 58,491,334 tons, of which the United States produced 29.74%, Spain 19.37%, Germany 13.32%, Great Britain 9.67%, Mexico 6.20% and each of the other twenty countries less than 3% each. AHE

Strontium from a Domestic Viewpoint. R. M. Santmyers. *Economic Paper* No. 4, *United States Bureau of Mines*, 1929, 19 pages.

Domestic and foreign deposits of strontium minerals are described. Since 1918 the United States has imported its entire supply (4,233,816 pounds in 1927; value, $149,383). Among its uses is that of a copper alloying element to act as a hardening agent and to free castings from blow holes. AHE

Summarized Data of Zinc Production. Elmer W. Pehrson, et al. *Economic Paper* No. 2, *United States Bureau of Mines*, 1929, 47 pages.

A single large table shows the production of zinc by countries from 1801 – 1927, by decades from 1801 – 1870 and annually from 1870 – 1927. The total production was 37,222,948 tons, of which the United States produced 31.21%, Germany 27.85%, Belgium 19.34%, Great Britain 6.04%, France 5.29% and each of the 17 other countries less than 2%. AHE

Historical Summary of Gold, Silver, Copper, Lead and Zinc Produced in California, 1848–1926. James M. Hill. *Economic Paper* No. 3, *United States Bureau of Mines*, 1929, 22 pages.

Since gold was first discovered in California in 1848, $2,059,427,841 worth of gold, silver, copper, lead and zinc have been produced. Of this total the gold output was 87.46%; silver, 3.29%; copper, 8.19%; lead, 0.63%; and zinc, 0.43%. A total of 663,763 tons of metal have been produced, distributed as follows: copper, 75.67%; lead, 16.37%; zinc, 7.10%; gold, 0.45%; and silver, 0.41 %. AHE

Gold, Silver, Copper, Lead and Zinc in Washington in 1927. C. N. Gerry. *Mineral Resources of the United States*, 1927, Part I; *United States Bureau of Mines*, 1929, pages 589–598.

The value of the production of gold, silver, copper, lead and zinc decreased 8% to $854,659 in 1927. Increases in the value of gold, copper and zinc were more than offset by large decreases in lead and lesser ones in silver. Production of gold was 19,513.51 ounces; silver, 155,850 ounces; copper, 1,685,848 pounds; lead, 955,003 pounds; and zinc 1,278,710 pounds. Gold production was more than twice that in 1926, silver production decreased 9%, copper increased 25%, lead decreased 79% and zinc increased 23%. AHE

Gold, Silver, Copper, Lead and Zinc in Idaho in 1927. C. N. Gerry. *Mineral Resources of the United States*, 1927, Part I, *United States Bureau of Mines*, 1929, pages 573–588.

The value of gold, silver, copper, lead and zinc production in Idaho decreased from $30,969,551 in 1926 to $28,104,413 in 1927 chiefly due to the decline in prices of lead and zinc. The quantity of all metals produced increased. Gold production increased 12%; silver, 12%; copper, 62%; lead, 11%; and zinc, 2%. Production in these were, respectively, 15,315.67 ounces, 8,901,409 ounces, 2,173,163 pounds, 302,038,423 pounds and 53,556,345 pounds. AHE

Platinum and Allied Metals in 1928. V. C. Heikes. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, 1929, pages 7–20.

In 1928, 528 ounces of crude platinum were produced in the United States (153 ounces in 1927). Imports of crude platinum were 108,447 ounces, a decrease of 16%, of which 52,800 ounces came from Columbia. Refiners of crude platinum, gold bouillon and copper recovered 59,039 ounces of platinum metals, an increase of 28%. AHE

Antimony in 1928. Paul M. Tyler. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, 1929, pages 89–104.

In 1928 the apparent consumption of antimony declined still more than in 1927. Shipments from China increased. Production of antimonial lead from domestic ores in 1928 was 17,930 short tons, with an antimony content of 2,105 tons; from foreign ores the corresponding figures were 15,128 and 1,327 tons, respectively. The recovery from old alloys, scrap and dross was 11,900 tons. World sources are discussed. AHE

Arsenic, Bismuth, Selenium and Tellurium in 1928. V. C. Heikes. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, 1929, pages 1–6.

Production of arsenic in the U. S. in 1928 amounted to 14,163 short tons, of which 9,276 tons was refined. Nearly all the output was a by-product from copper and lead smelting. World production by countries for 1924–1927 is given. Bismuth was recovered at 2 refineries. Selenium was produced by 3 companies. The estimated output of tellurium was 2650 pounds, an increase of 1000 pounds over 1927. AHE

Zinc in 1928. Elmer W. Pehrson. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, 1930, pages 363–421.

Production of primary zinc from domestic ores totaled 591,525 short tons (2.5% increase) and from foreign ores 11,056 tons (29% decrease) in 1928. Electrolytic zinc amounted to nearly 27% of the total production (19% in 1927). Montana replaced Oklahoma as the leading producer. Recovery of secondary zinc increased 7% to 70,700 tons. World smelter production increased 7% to 1,555,000 tons. The brass industry showed the largest tonnage increase in the use of zinc, while die casting exhibited the largest percentage increase. Galvanizing used more zinc in 1928 while rolled zinc production decreased. AHE

Secondary Metals in 1928. J. P. Dunlop. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, 1929, pages 145–167.

Figures for production of secondary copper, zinc, lead, tin, antimony, aluminum and nickel are given. The Standard Classification for Old Metals, Effective from March 1, 1928, drawn up by the Metal Division of the National Association of Waste Material Dealers, is given. AHE

Chromite in 1928. Lewis A. Smith. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, 1929, pages 69–88.

The most noteworthy developments of 1928 included the extensive adoption of chromium plating (especially for automobile parts) and the increased use of rustless iron and steel and nickel-chromium steels. Shipments of chromite from mines in the U. S. in 1928 were more than 3 times those in 1927, but still relatively insignificant. Imports totaled 216,592 long tons, 49% of the world output. Southern Rhodesia furnished more than half of this. Uses and the world production by countries are discussed. AHE

Summarized Data of Copper Production. C. E. Julian, et al. *Economic Paper* No. 1, *United States Bureau of Mines*, 1928, 32 pages.

A single large table shows the production of copper by countries from 1801 to 1927, by decades from 1801 to 1880 and annually from 1881 to 1927. Production in this period has amounted to 40,498,322 tons, of which the United States produced 48.43%, Chile 11.22%, Spain and Portugal 6.97% Japan 6.03%, Mexico 3.91%, Australasia 3.53%, Germany 3.25 and each of the other 22 named countries less than 3% (miscellaneous countries account for 0.74%). AHE

Manganese and Manganiferous Ores in 1928. Lewis A. Smith. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, 1929, pages 205–259.

In 1928, 46,860 long tons of domestic ore containing 35% or more of manganese were produced, about $^1/_3$ chemical and $^2/_3$ metallurgical ore. Imports were 427,708 tons of ore and 48,844 tons of manganese in ferromanganese. AHE

Rare Metals. Cobalt, Molybdenum, Tantalum, Titanium, Tungsten, Radium, Uranium and Vanadium in 1928. Frank L. Hess. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, 1929, pages 105–143.

In 1928 the United States produced no *cobalt* but imported over a million pounds of cobalt, cobalt ore and cobalt oxide. Belgium and Canada were the big producers. Its chief use is in stellite. Three companies produced 328,989 short tons of *molybdenum* ore, carrying 1,714 short tons of metallic molybdenum. From a production of 2100 and 1100 pounds of columbite (*tantalum* ore) in 1926 and 1927, respectively, the amount increased to 34,899 pounds in 1928. All of this was produced in South Dakota and most was exported to Liverpool and Germany. Domestic production figures of rutile and ilmenite (*titanium ores*) can not be given. Imports, chiefly from India, totaled 17,224 short tons of ilmenite. In 1928, the United States produced 1208 short tons of *tungsten* concentrates (60% WO_3) and imported concentrates equivalent to 3001 tons more, chiefly from China. In 1928 no *radium* was isolated in the United States, although foreign trade increased. The *vanadium* production is controlled by one company and production figures are not available. A bibliography with abstracts of the most important literature of the year on each of these metals fills more than half of the space. AHE

Japanese Iron and Steel Industry. *Iron & Coal Trades Review*, Nov. 15, 1929, Vol. 119, pages 741–742.

Review of the year ended June 30, 1929 giving production of iron ore, pig-iron, steel and steel products for the years 1926–1928. Exports and imports are given. RHP

Iron Ore, Pig Iron and Steel in 1928. Hubert W. Davis. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, 1929, pages 29–68.

In 1928 the production (62,197,088 tons) and shipment of iron ore increased 1 and 4%, respectively, as compared with 1927. The output (37,-410,897 tons) and shipment of pig iron increased 4 and 10%, respectively. The output (757,131 tons) and shipment of ferro alloys increased 7 and 23%, respectively. Bessemer steel production (6,620,195 tons) increased 7% and open hearth (44,113,956 tons) 16%. Of the latter, 43,200,483 tons were basic process and 913,473 tons acid. Electric process steel increased 20% (802,260 tons.) The automobile industry for the first time was the major consumer (18%). Constructional work accounted for 16.5% (first in 1927 with 22%). Railroads (first until 1927) were third (16%). Output of pig iron was about 74% of capacity. AHE

Production of Iron and Steel in Japan. *Iron & Coal Trades Review*, Nov. 1, 1929, Vol. 119, page 664.

Brief review of the iron and steel industry of Japan. Gives production of pig-iron and ferro-alloys from 1912 to 1928. Gives statistics on number, capacity and distribution of blast furnaces in Japan. RHP

Mercury in 1928. Paul M. Tyler. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines* 1929, pages 261–284.

During 1928, high prices, better metallurgical and mining technique, and expectations of increased consumption combined to stimulate in the United States a search for new mines, the development of prospects, the reworking of abandoned low-grade mines and old dumps and an increase in output from 11,276 (26 mines) to 18,108 flasks (54 mines). Imports decreased from 20,207 to 14,756 flasks. AHE

Economic Aspects of Sponge Iron Production in Canada. Bradley Stoughton. *Canadian Mining & Metallurgical Bulletin*, No. 215, March, 1930, pages 345–350; *Iron Age*, Vol. 125, March 30, 1930, page 790.

The advantages of sponge iron over scrap are (1) it contains no nickel, copper, chromium, etc., (2) it is low in combined oxygen, (3) steel which has been oxidized by a black slag in the electric furnace can never be deoxidized to the same quality, (4) steel scrap which has been oxidized in the open-hearth furnace gives a lower quality crucible steel after remelting than does wrought iron, and (5) it is claimed that the SiO_2 in sponge iron serves to flux and collect non-metallic inclusions. The disadvantages of sponge iron are (1) possibility of only partial reduction, (2) non-uniform in composition, (3) frequent objectionable impurities, (4) spongy condition favors oxidation, and (5) it is usually more expensive than equally good materials. The conditions which make a sponge iron industry economical are (1) rich ores low in phosphorus and sulphur or very low in price; (2) a reducing agent and fuel low in sulphur, (3) a reduction process complete in one operation, (4) a process that will produce a reasonably uniform product, and (5) a nearby market for a goodly amount of high-quality steel at high prices or a scarcity of steels crap and a lack of fuel suitable for blast-furnace smelting. AHE&VSP

Determination of Heat Treating Costs. *Fuels & Furnaces*, Dec. 1929, Vol. 7, pages 1876–1878, 1882.

Discusses factors influencing production costs and method of determination of costs. MS

Some Economic Aspects of the Copper Industry. L. C. Graton. *Bulletin* No. 208, *Mining & Metallurgical Society of America*, Vol. XXIII, Jan. 1930, pages 5–41.

This article discusses the copper production and consumption in the United States and the world, the relation of consumption to price, future prices, curtailment and stabilization, mine promotion, importation and tariff.

Tin in 1928. Charles White Merrill. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, 1930, pages 321–346.

The United States produced only about $^1/_{26}$ of 1% of the virgin tin it consumed in 1928. Nearly $^1/_3$ of the domestic supply was recovered as secondary tin. The world production in 1928 was 179,000 long tons (12% increase). Federated Malay States produced 35%; Bolivia, 23%; and the Netherland East Indies, 20% (78% of the total). Straits Settlements smelted 49%; the United Kingdom 33% and the Netherland East Indies, 14% (96% of the total). Imports to the United States were about 78,000 long tons while reclaimed tin amounted to about 32,000 tons. The United States is the leading tin consumer of the world. World trade by months for 1927 and 1928 is traced by detailed figures of shipments, deliveries and stocks. AHE

MISCELLANEOUS

Melting Platinum New Candlepower Standard. *Electrical World*, March 22, 1930, Vol. 95, page 600.

Pure platinum fuses at 3220° F. The brilliancy of the molten platinum is observed during the ten minutes elapsing just before it returns to the solid state. By means of photometric comparison the light emitted by the molten platinum is compared with the lamp standards of the U. S. Bureau of Standards. The platinum is c. p. within 4 parts per 1,000,000. WHB

New Tin Compound Improves Heavy Machinery. *American Metal Market*, Feb. 25, 1930, Vol. 37, No. 38, page 4.

A new compound for tinning cast iron and of probable value in the manufacture of bearings in Diesel engines, air compressors and other heavy machinery has just been announced by Anglo-Oriental Mining Corp. Ltd. The compound consists of pure tin and a secret flux. The metal is heated and the powder sprinkled on it. Any metal except aluminum can be tinned without previous cleaning. WHB

Rarer Elements in the Glass Industry. H. Conrad Meyer. *The Glass Industry*, March 1930, Vol. 11, page 63.

The uses of the oxides of the rare metals cerium, didymium, titanium, uranium and zirconium, in special glasses is briefly described. Iron chromite and selenium also appear on the list. WHK

What is a Bronze? *Iron Age*, Jan. 16, 1930, Vol. 125, pages 236–237.

Condensed from letter circular No. 268 of the U. S. Bureau of Standards, states that an alloy of copper and tin containing 50% or more of copper and no other alloying metal besides tin, is a bronze. Outside of a very few alloys the tin content is usually under 20%. Alloys containing 3 elements the name of the third added element is used before the word bronze. Logical systems are cumbersome with a four-component alloy. The terms applied are either composition metal, or where a definite specification exists, reference to the specification number is made. VSP

Value of Research to Manufacture. George L. Kelly. *Iron Age*, Jan. 23, 1930, Vol. 125, pages 291–293.

Industrial laboratories are occupied chiefly with research devoted to 3 aims: 1. The development of new products. 2. The improvement of old products. 3. The improvement of methods of manufacture of old products in order to better the products or reduce costs. Specific discussion of investigations is given on press and die design, quality of sheet metal and welding of steel auto bodies. VSP

Failure and Life of Steam Boilers in Relation to the Stress and Fatigue of the Materials. (Schäden und Lebensdauer der Dampfkessel in ihrer Abhängigkeit von der Beanspruchung und Schwingungsfestigkeit der Werkstoffe.) M. Ulrich. *Veröffentlichungen des Zentral-Verbandes der Preussischen Dampfkessel-Ueberwachungs-Vereine.* 1929, Vol. V, pages 7–14.

Illustrations are given of the 3 types of steam boiler failures. 1. Sudden fracture after stretching and reduction of cross section. 2. Sudden fracture without deformation, and 3. Progressive fracture without deformation (fatigue). From tests with boiler plate the ratio $\frac{\text{endurance limit}}{\text{yield point}} = 0.7$ was derived. Riveted steam boilers are usually designed with a factor of safety of 4:1, but the actual service stresses at times exceed the calculated allowable stresses considerably. Nevertheless, a life of 45 years, which may be considered indefinite, is obtained. The explanation is that the number of stress reversals per unit of time is comparatively low. A curve is worked out showing the relation between the stress on the boiler material and the life of the boiler before failure. With a pressure equivalent to the endurance limit the life will be 45 years, but with an increase of 2 kg./mm.^{2} the life is reduced to 25 years and with further increase of 3 kg./mm.^{2}, which reaches the yield point, the life is reduced to about 2 years. CEM

The Significant Properties of Automotive Lubricants. H. C. Mougey. *Preprint* March 1930, *Automotive Symposium, American Society for Testing Materials*, 10 pages.

The coefficient of friction and the tendency of a bearing to seize are not necessarily interrelated. Lard oil has a lower coefficient of friction, but will allow a bearing to seize at 13,000 lbs./in^2., while special compounded mineral oil transmission lubricants will operate without seizure at twice that pressure. Dilution of crankcase oil does not appear to be a cause for burnt-out bearings and scored cylinders. In a test, bearings were cut away to $^1/_3$ their original area, very thin oil used, and the oil kept at 300° F., and no bearing trouble experienced. "If the bearing clearance had been greater the thin oil might have increased the pounding effect in the bearings, and it is possible that under these conditions, failure could have occurred due to fatigue of the bearing metal." "Oiliness" of a lubricant is determined using a hardened steel shaft and a bushing of the same, at 100 r. p. m. increasing the load till seizure takes place. Oiliness is required with certain types of rear axles, but does not appear to be of much importance in automobile engines under normal operation. No discussion is given of any specific property of the metal in bearings, gears, etc., by which one metal may hold the oil film more firmly than another. HWG

Pyrophoric Iron. T. G. Finzel. *Journal American Chemical Society*, Jan. 1930, Vol. 52. I. Preparation and Properties, pages 142–149. II. Adsorption of Carbon Dioxide and Ammonia and the Use of Pyrophoric Iron in the Ammonia Synthesis, pages 150–156.

Pyrophoric iron can best be prepared by reducing precipitated ferric oxide by hydrogen at 500° C. Chlorides destroy the pyrophoric character. For a given material inactivation is dependent not only upon the temperature and time of heating, but also upon the gaseous medium in which it is heated. Iron was found to be pyrophoric in dried air and also in air cooled to −78°. It was found that adsorption of carbon dioxide by pyrophoric iron is no criterion for pyrophoric action, a sample of non-pyrophoric iron adsorbing more gas than a sample of pyrophoric iron. It appears that adsorption of carbon dioxide and ammonia is dependent upon residual oxide in the preparation. Iron prepared from colloidal iron oxide by Sorum's method was worthless as an ammonia catalyst, but the incorporation of colloidal aluminum oxide in the colloidal iron oxide produced an active catalyst. MEH

Translation

Negotiations are under way which will assure the appearance of translations of articles appearing in foreign publications. Under this arrangement, the readers of METALS & ALLOYS *will be assured of receiving in English the best articles shortly after they appear abroad.*

The Effect of Quenching and Drawing below the A_1 Point upon the Physical Properties of Iron-Nitrogen Alloys

By Werner Köster, Dortmund, Germany

Report of the Research Laboratories of Vereinigte Stahlwerke, A. G. Dortmund, Germany. Translated by special arrangement from Archiv für das Eisenhüttenwesen, Vol. 3, Feb. 1930, pages 553–558.

According to A. Fry,[1] that branch of the iron-nitrogen constitutional diagram which relates to transformations occurring after solidification bears a great resemblance to the constitutional diagram of the iron-carbon alloys (Fig. 1). On cooling, the solid solution gamma-iron-nitrogen decomposes into the solid solution alpha-iron-nitrogen and a nitride whose composition has been given as Fe_4N. The eutectic known as "Braunite" occurs at about 1.5% nitrogen and 580° C. and has a lamella structure similar to that of pearlite. The solid solution alpha-iron which forms at this eutectic temperature contains about 0.5% nitrogen. With decreasing temperature the solubility of the alpha-iron for nitrogen decreases. At room temperature it is about 0.015% nitrogen. Along this line of decomposition the nitrogen precipitates out in the form of very thin lamellae which in the micrograph usually appear as fine needles.

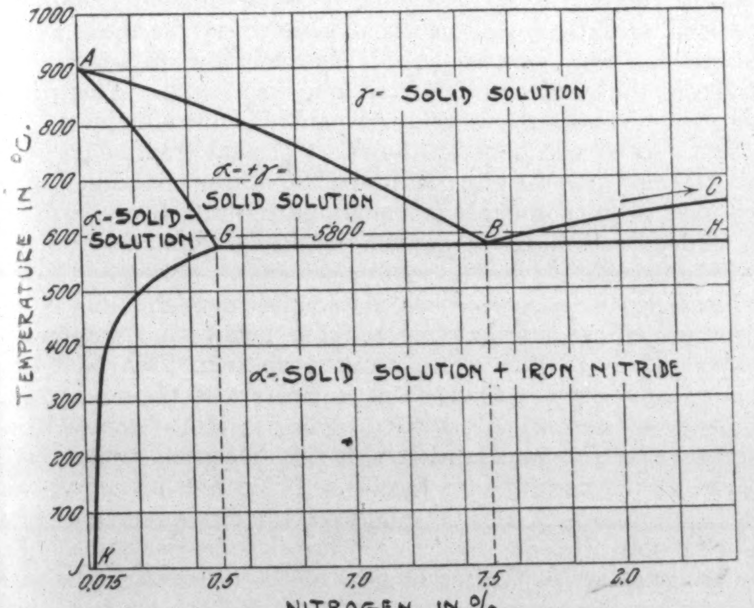

Fig. 1—Constitutional Diagram Iron-Nitrogen

The decrease of the solubility of nitrogen in alpha-iron points to the possibility of effecting an important change in the physical properties of iron-nitrogen alloys by means of a heat treatment below the eutectic temperature. We might mention in particular the possibility of hardening these alloys in a manner similar to what obtains in duralumin. Such a possibility results from the recognition of the capability of iron carbon alloys to harden like duralumin, which has been pointed out by G. Masing and L. Koch[2] and by the author,[3] as well as from the change in the physical properties caused by the separation of carbon from the super-saturated solid solution alpha-iron. An investigation into iron-nitrogen alloys from this standpoint appears to be of particular interest in view of the fact that it appeared to be possible to unequivocally ascertain the effect of nitrogen upon iron. The results obtained are published herewith.

It does not appear to be possible to incorporate considerable amounts of nitrogen in molten iron. B. Strauss[4] reports 0.03–0.04% nitrogen as an upper limit. However, it is easily possible to introduce larger amounts of nitrogen into solid iron by heating it in ammonia. An inconvenience of this method, however, resides in the fact that only an outer layer in case of samples subjected to this treatment contains appreciable quantities of nitrogen; the nitrogen content decreases gradually toward the core of the samples. This method, nevertheless, is sufficiently accurate as an investigation into the fundamental behavior of the iron-nitrogen alloys.

The samples used in the experiments were electrolytic iron which had been melted in vacuum, and a steel of low carbon content. Table I gives the chemical compositions of the materials used. The steel with 0.20% carbon was used for investigating the changes in the mechanical properties and the steel with 0.10% carbon for investigating the changes in the magnetic properties.

Table I—Chemical Compositions of the Samples Used

Material	C %	Si %	Mn %	P %	S %
Vacuum melted electrolytic iron	0.01	0.01	0.03	0.008	0.008
Steel with 0.20% C	0.20	0.13	0.62	0.060	0.064
Steel with 0.10% C	0.10	0.01	0.43	0.043	0.051

In these experiments the samples were annealed in ammonia at 550° C. for 6 hours. The nitrided case had a thickness of about 0.5 mm. and had an average nitrogen content of 0.12%. The bars had a diameter of 5.6 mm.

The Effect of the Heat Treatment upon the Structure and upon the Physical Properties

a. Electrolytic Iron. As may be seen from Fig. 2, the micrograph of this sample shows nitride needles the size of which decrease from the surface toward the interior of the sample.

Since the nitrogen concentration decreases from case to core it is seen that the needles are the finer the lower the nitrogen concentration; or, which is the same, the lower the temperature at which the needles are separated out. It may furthermore be observed that the needles are arranged in a manner corresponding to the crystallographic texture of the ferrite.

Quenching from higher temperatures causes the disappearance of the nitride needles. Fig. 3 shows the structure of the nitrided case after quenching from 550° C. Only ferrite crystals are visible; the outermost portions of the case are composed of the super-saturated solid solution of alpha-iron. Drawing the quenched alloy causes the separation of the iron nitride. Fig. 4 shows the structure of a sample drawn at 250° C. The separations are again needle-like, arranged similar to crystals, and exceedingly fine. As may be expected, their number decreases from the case toward the core.

The physical properties of nitrided electrolytic iron which correspond to the treatments mentioned, are given in Table II. Fig. 5 shows the tensile specimens after breaking. We may say here that the effect of nitrogen upon the iron involves an increase in the tensile strength and a decrease in the elongation. Apart from this there is nothing remarkable about slowly cooled samples of this material; they neck down considerably and exhibit a fibrous fracture. The rapidly cooled sample, however, has completely lost its ductility. During the tensile tests these specimens broke at various points of the gage length with a ringing sound. The first sounds were observed at a load of about 12,800–14,200 lbs./in.².

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[1] *Krupp'sche Monatshefte,* Vol. 4, 1923, pages 137–151.

[2] *Wissenschaftliche Veröffentlichungen des Siemens-Konzern* Vol. 6, 1927, pages 202–210; *Archiv für das Eisenhüttenwesen,* Vol. 2, 1928–29, pages 185–196.

[3] *Archiv für das Eisenhüttenwesen,* Vol. 2, 1928–29, pages 194–195 and 503–522.

[4] *Sta hl und Eisen,* Vol. 34, 1914, page 1817.

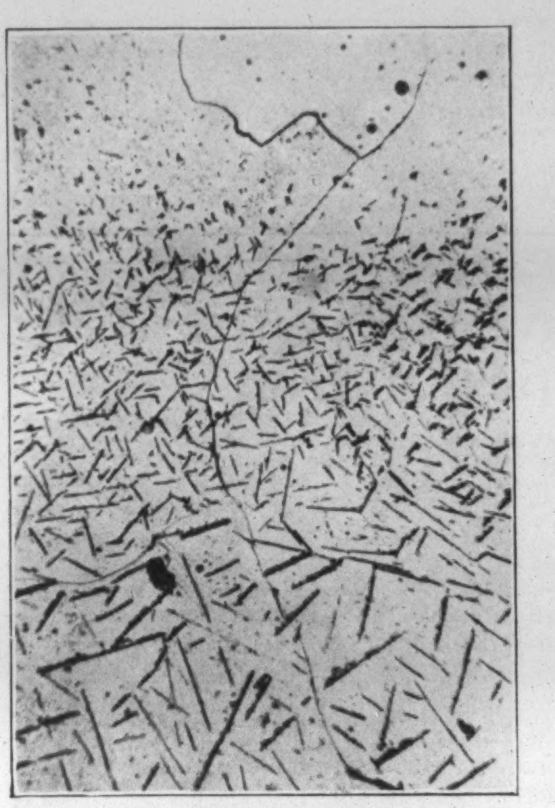


Fig. 2—Nitrided Electrolytic Iron Cooled Slowly from 550° C. (× 200)

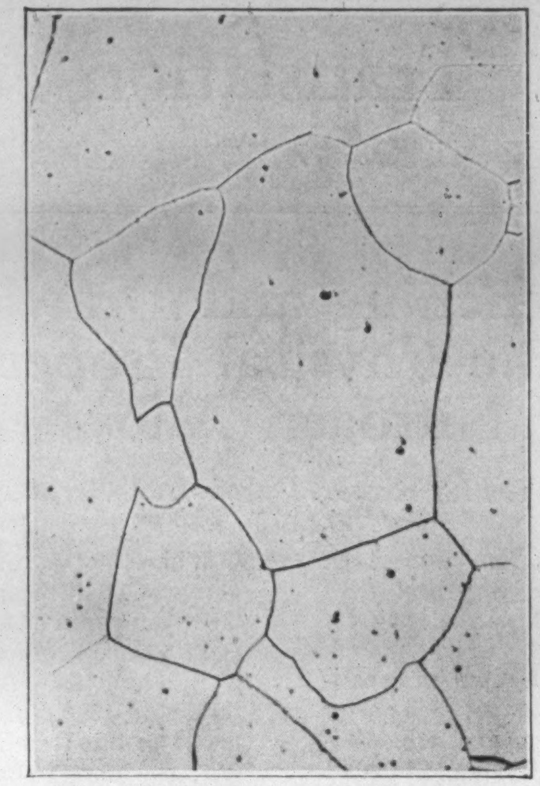


Fig. 3—Nitrided Electrolytic Iron Quenched from 550° C. (× 200)

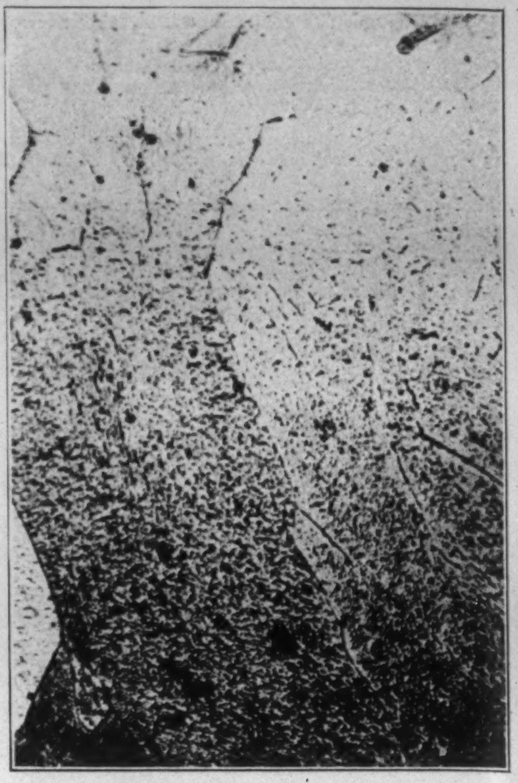


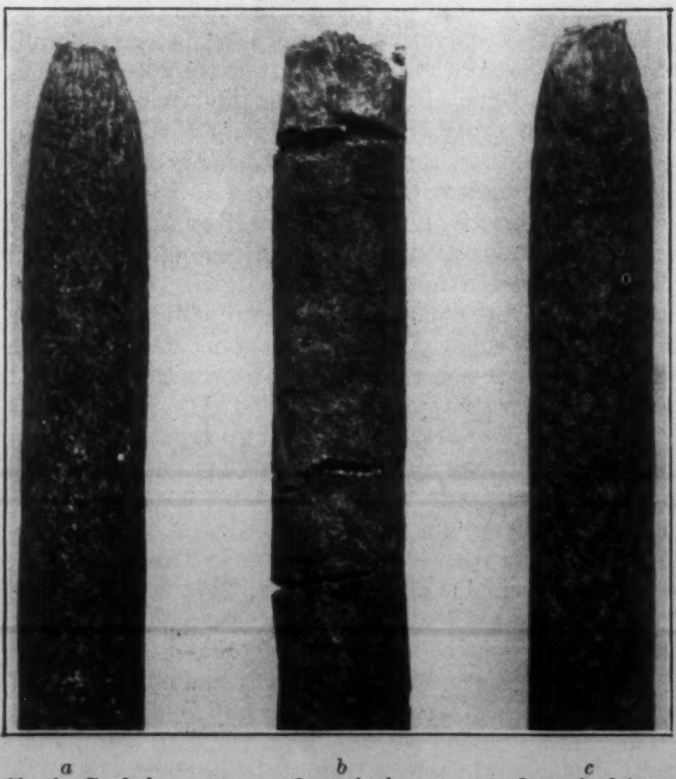
Fig. 4—Nitrided Electrolytic Iron Quenched from 550° C. and Drawn at 250° C. (× 200)

The fracture was crystalline with a more or less easily visible tough fibrous core. This proves that the brittleness is confined to the nitrided case. A further proof is furnished by the fact that after removal of the nitride coating the core, when subjected to tensile tests, necks and exhibits a tough fracture. After tempering at 250° C., the test bar necks in a manner similar to the untreated bar.

Table II—Physical Properties of Nitrided Electrolytic Iron after Different Heat Treatments

Heat Treatment	Yield Point lbs./in.^{2}	Tensile Strength lbs./in.^{2}	Elongation %	Reduction of Area %
Untreated	22,000	38,000	48	87
Nitrided and cooled slowly	23,000	40,500	35	81
Quenched at 550° C.	28,500	45,000	..	..
After quenching drawn at 520° C.	24,500	45,500	30	80

These facts show that the state of the nitrogen contained in iron exerts a considerable influence upon the properties of the iron. Non-uniformly distributed iron nitride has little influence upon the mechanical properties, while the solid solution of nitrogen in iron is very brittle. The brittleness manifests itself directly after the quenching; aging at room temperature has no further influence upon the results of tensile tests.



a
Slowly Cooled from 550° C.

b
Quenched from 550° C.

c
Quenched from 550° C., drawn at 250° C.

Fig. 5—Tensile Tests of Nitrided Electrolytic Iron After Different Heat Treatments

It remained to be ascertained whether the super-saturated solid solution experiences a hardening effect in a manner similar to what obtains in duralumin. For this purpose the behavior of a quenched specimen with respect to its hardness was studied experimentally during its aging at 20° C. This sample had been nitrided thoroughly by subjecting it to the influence of ammonia for long periods of time, so that satisfactory hardness figures (2.5/62.5) were measured. As is shown in Fig. 6, a further increase in the hardness of this sample was found. This proves that iron-nitrogen alloys are hardenable like duralumin.

The data given above on the effect of heat treatments below the A_1 point upon the physical properties of iron containing nitrogen have been thoroughly corroborated recently by R. S. Dean, R. O. Day and J. L. Gregg[5] who studied electrolytic iron with 0.07% nitrogen.

The following observations are to supplement the data on the structure of the nitrogen precipitated below the temperature corresponding to the eutectic transformation. We have said above that the size of the needles decreases with the temperature of the precipitation. With slow cooling it must be noted that the ferrite matrix shows innumerable very fine needles between the coarse nitride needles (see Fig. 7). These precipitations, take place below 300° C. and they indicate the decomposition of the solid solution whose concentration has become very weak after the precipitation of the major part of the nitrogen. The mass of these fine needles, when compared to that of the coarse needles, is very small.

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[5] *Stahl und Eisen*, Vol. 49, 1929, pages 1095–1096.

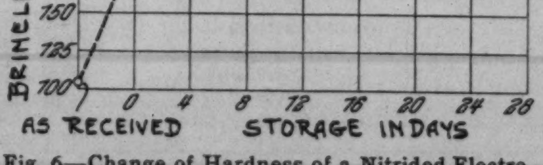

Fig. 6—Change of Hardness of a Nitrided Electrolytic Iron Sample Quenched from 550° C. on Storing at 20° C.

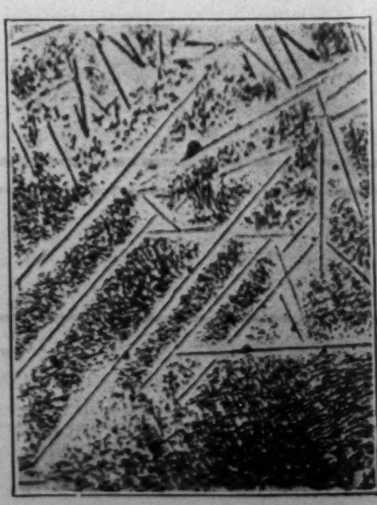

Fig. 7—Structure of a Slowly Cooled Iron-Nitrogen Alloy. (× 200)

A deposition of the nitrogen upon the existing needles takes place only in the very close proximity thereof, in view of the decreased speed of diffusion. This explains the pure ferrite envelopes surrounding the needles. The same form of precipitation is also encountered at the border of the nitrided zone which faces the core, that is, in the zones of lowest nitrogen concentration (see Fig. 8). During the tempering these fine needles enter the solid solution first, as is easily understood, since their mass is small and their dispersion great. These fine precipitations are the cause of remarkable magnetic properties of these alloys, which are described below.

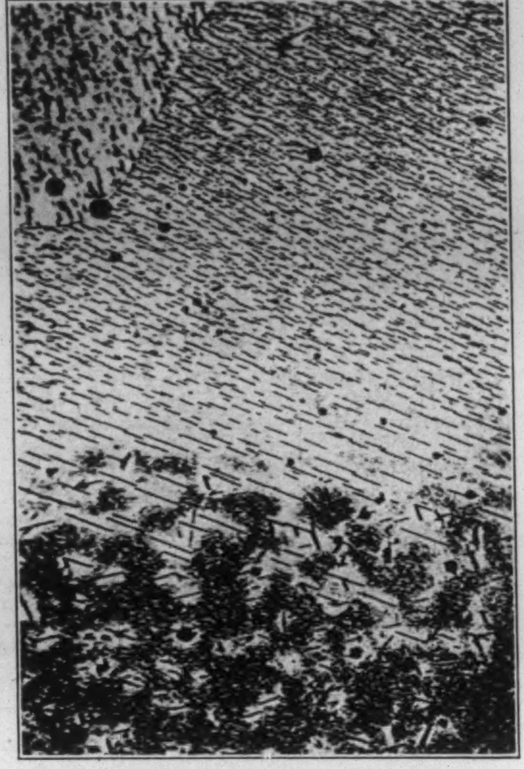

Fig. 8—Structure of the Low Nitrogen Zone Bordering on the Core. (× 200)

b. Mild Steel. The effect of nitrogen upon carbon-containing iron is fundamentally the same as its effect upon iron which is practically free from carbon. The nitrided mild steel specimens were first annealed at 920° C. and cooled slowly. The nature of the precipitation of the nitrogen from the ferrite is noteworthy. In addition to the needles there is usually found a maze of small dots forming a conglomeration in the proximity of the eutectoid fields.

The physical properties of the untreated and treated mild steel specimens were as follows:

	Yield Point lbs./in.^{2}	Tensile Strength lbs./in.^{2}	Elongation %	Reduction of Area %
Untreated	45,500	72,500	26	60
Nitrided	49,000	77,000	26	56

As with electrolytic iron, the treatment of mild steel results in a small increase in the tensile strength.

Table III depicts the influence of quenching at temperatures increasing from 100–730° C. Above 400° C. the working properties of the samples deteriorate rapidly; the fracture is brittle and crystalline. Coincidentally, at 400° C. there becomes visible a decided decrease in the size of the nitride needles; above 500° C. they are absent. Furthermore, at a quenching temperature of 600° C. the eutectoid islands located at the periphery have become transformed into martensite. These observations correspond to the constitutional diagrams. The temperature of the nitrogen eutectoid is 580° C. and that of the carbon eutectoid is 720° C. With intervening temperatures it is always possible to recognize eutectoid fields at the border lines, said fields being partly hardened, partly unaffected by the transformation. This shows that the A_1 point of a steel is reduced by the incorporation of nitrogen in the pearlite.

Table III—Influence of Quenching upon the Physical Properties of Nitrided Steel

Quenching Temperature ° C.	Yield Point lbs./in.^{2}	Tensile Strength lbs./in.^{2}	Elongation %	Reduction of Area %	Fracture
Normalized	49,000	77,000	26	56	Fibrous
100	45,500	75,000	22	55	Fibrous
200	44,500	71,000	23	55	Fibrous
300	48,000	78,000	34	52	Fibrous
400	48,500	79,000	22	52	Fibrous
500	50,500	78,000	11	10	Crystalline
600	55,000	71,000	3	8	Crystalline
680	62,000	89,500	10	9	Crystalline
730	91,000	110,000	10	10	Crystalline

Table IV gives data on the changes in the physical properties of a nitrided steel quenched at 550° C. and subsequently drawn. The duration of the treatment was one hour. After drawing at 150° C., the working properties of the steel were completely restored; the fracture was fibrous.

Coincidentally with this, the first nitride precipitations were observed at 150° C. They were in the form of extremely fine needles. With increasing drawing temperature the size of the needles increased. At the border of the nitrided zone toward the core there became visible first a few fine dots corresponding to the decomposition of the solid solution containing the least amount of nitrogen. The number of these dots increased and gradually the structure assumed the form including nitride needles.

Table IV—Effect of Annealing upon the Physical Properties of Nitrided Steel after Quenching at 550° C.

Drawing Temperature ° C.	Yield Point lbs./in.^{2}	Tensile Strength lbs./in.^{2}	Elongation %	Reduction of Area %	Fracture
Quenched	52,500	77,000	9	6	Crystalline
100	52,500	81,500	10	8	Crystalline
150	52,300	79,500	20	54	Fibrous
200	52,000	80,500	24	55	Fibrous
300	47,000	77,000	24	55	Fibrous
400	43,000	72,500	24	59	Fibrous
500	47,500	77,000	24	52	Fibrous
600	48,500	76,000	23	51	Fibrous
680	46,000	73,000	26	59	Fibrous

The Effect of Heat Treatments on the Magnetic Properties

In the original condition the electrolytic iron had the following properties:

Coercive Force: 1.5 gauss
Remanence: 5850 gauss
Electric Conductivity: 9.28 $\dfrac{\text{m}}{\Omega.\ \text{mm.}^2}$

After the nitrogen treatment the coercive force had increased to 4, the remanence to 9500, and the conductivity was reduced to 8.8. This shows the detrimental influence of nitrogen upon the magnetic properties of iron, particularly the deleterious effect upon the hysteresis.

The nitrogen-treated electrolytic iron bar was then quenched at increasing temperatures. Fig. 9 gives the results of tests. The conductivity varies in the manner to be expected, that is, it decreases rapidly as the rate of formation of the solid solution increases. At 600° C., that is, just above the eutectoid temperature, the conductivity becomes constant, the nitrogen now being dissolved in all layers.

The behavior of the coercivity is noteworthy. After a slight increase, the cause of which is discussed below, it falls rapidly from 150–300° and thereafter remains substantially constant. The temperature range mentioned coincides with that in which the small needles precipitated out last after the nitriding, as explained above, reenter into solution. Consequently, the coercivity depends upon entirely different conditions during the same change of state of the alloy as does the electric conductivity. In this connection a particularly interesting observation tends to prove that the coercivity is primarily influenced by the distribution of the phases and is particularly susceptible of enhancement if the size of the particles approximates the limit of microscopic visibility, as has been disclosed by the author in another paper.[6]

However, if the larger needles have become dissolved and, owing to the more rapid formation of the solid solution, the conductivity begins to decrease rapidly, the coercivity remains

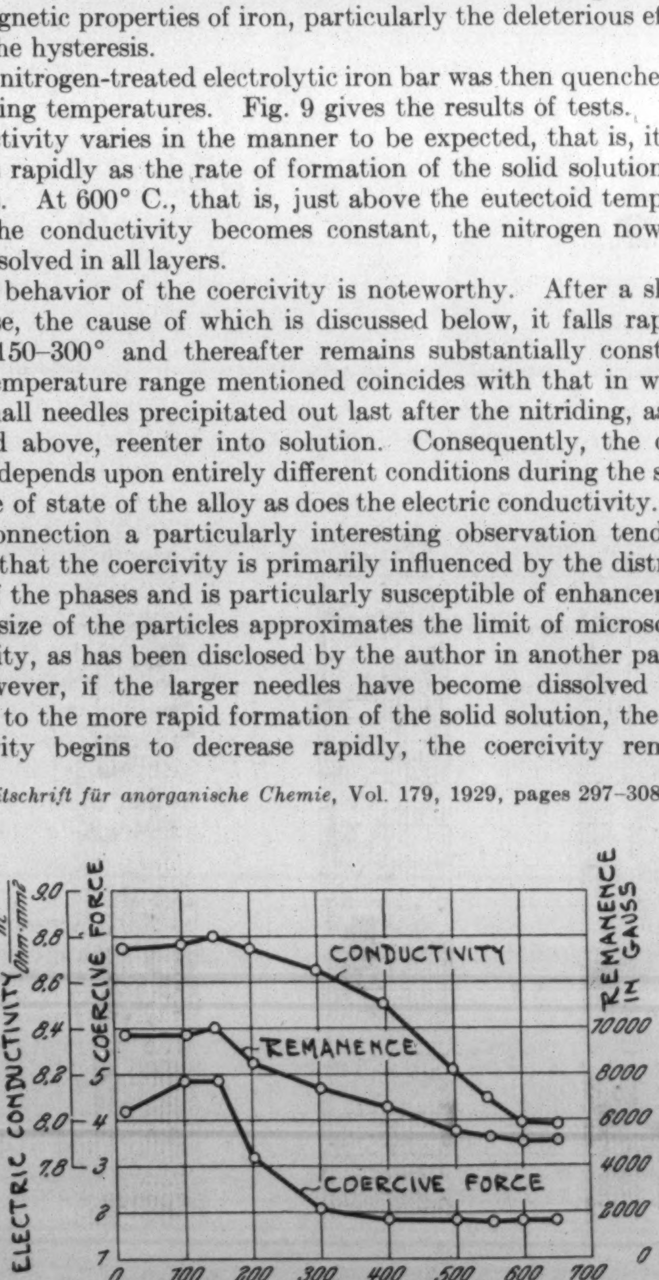

Fig. 9—Influence of Quenching on the Coercive Force, Remanence and Electric Conductivity of Nitrided Electrolytic Iron

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[6] *Zeitschrift für anorganische Chemie*, Vol. 179, 1929, pages 297–308.

constant. In this case it is not higher than in the initial state. This shows that the coercivity is substantially unaffected by the formation of the solid solution, but is strongly affected by a heterogeneous structure of the alloy. This has been pointed out recently by A. Kussman and B. Scharnow[7] who base their observations on several series of alloys.

In quenched specimens the remanence varies in a manner similar to the coercivity, but the variation is less pronounced. It decreases substantially linearly with the quenching temperature. The maximum permeability calculated from $\mu_{\text{max.}} = \frac{B_r}{2H_c}$, first increases and then slowly decreases.

Fig. 10 depicts the effect of tempering for one hour upon nitrided electrolytic iron quenched at 550° C. After the drawing, one of the specimens was cooled slowly, and the other was quenched in water. As may be expected, the coercive force increases rapidly with the drawing temperature, since during the decomposition of the super-saturated solid solution the iron nitride precipitates out in the form of very small needles which are visible under the microscope. The maximum value is attained at 150° C. With slower cooling rates the coercive force remains constant from this point on. If it is followed by quenching it decreases, but somewhat more slowly than is the case with the non-quenched specimen of Fig. 9. This is due to the fact that the precipitation of the total nitrogen content took place in very high dispersion.

In contradistinction to its behavior during the separation of cementite from ferrite, the remanence remains unchanged up to 250° C. It then increases slowly. With a slow cooling rate it returns to its initial value, namely, 10,000 gauss. With rapid cooling it decreases as in Fig. 9.

The effect upon the conductivity corresponds to the expectations.

Fig. 10 further shows the behavior of a more strongly nitrided specimen after quenching. The specimen was nitrided at 550° C. for 2 days, quenched from that temperature and aged for 14 days at 100° C. The coercive force scale for this specimen is measured by the right hand ordinate. The results corroborate the observations made above.

The tests carried out with the nitrided electrolytic iron were also applied to the nitrided mild steel which contained 0.10% carbon. Fig. 11 gives the drawing curves. As far as the effect of nitrogen is concerned, the variation in the physical properties of this material substantially corresponds to that of the other material. The deviations of this material which are at all noteworthy are to be explained by the simultaneous occurrence of the effect of the precipitation of cementite which, in accordance with prior experiments is already noticeable at a quenching temperature of 550° C. This additional effect is most pronounced in the drawing. Fig. 11 shows that the effect of the precipitation of cementite, superposes itself to that of the separation of nitrogen with respect to the coercive force. This is the more intelligible in this case since both phenomena take place substantially independent of each other within the core and within the case. This causes the increase of from 3–10 gauss. Consequently, the peak of the curve is now shifted to 250° C., corresponding to the precipitation of cementite. After this the curve assumes a downward trend and at 450° C. corresponds to the initial value. The curve representing the quenched specimens is always below that of the slowly cooled specimens.

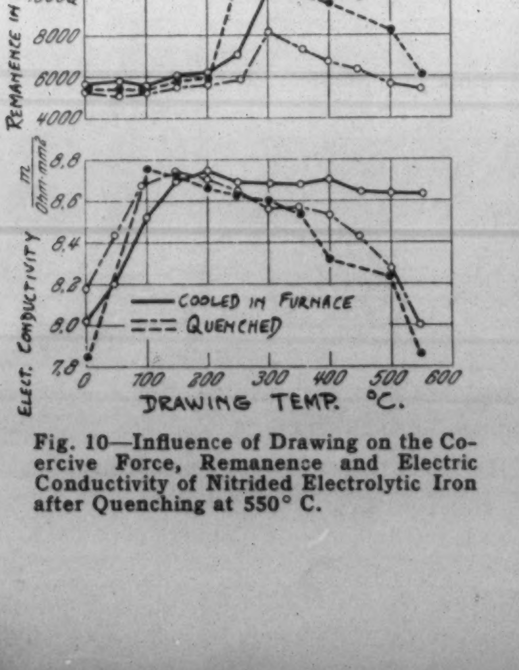

Fig. 10—Influence of Drawing on the Coercive Force, Remanence and Electric Conductivity of Nitrided Electrolytic Iron after Quenching at 550° C.

The fact that the difference between these 2 curves is maximum at 200–250° C. is due to the fact that, in accordance with Fig. 9, at these temperatures small quantities of nitrogen are dissolved, and that these quantities are those having the greatest dispersion and consequently are most effective magnetically. It may be inferred from Figs. 10 and 11 that at 150° C. a somewhat greater quantity of nitrogen is absorbed in solid solution than is at 100° C.

Owing to the simultaneous precipitation of cementite, the remanence increases at the lower temperatures in the same manner as if nitrogen alone were present.

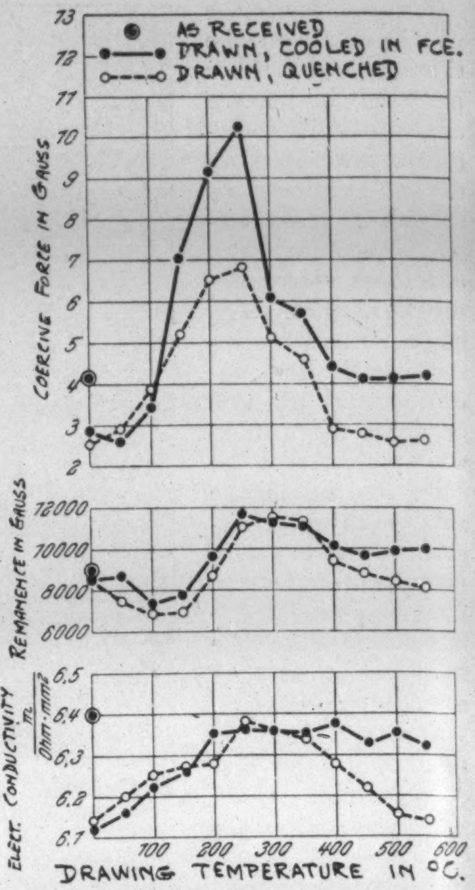

Fig. 11—Influence of Drawing on the Coercive Force, Remanence and Electric Conductivity of Nitrided Low Carbon Steel after Quenching at 550° C.

Fig. 12 shows the drawing isotherms corresponding to the properties studied of both materials at 100° C. At this temperature the electrolytic iron attains the original conductivity after about 4 days, that is, it is in a state of equilibrium. The coercive force increases in the same manner as the conductivity and reaches its maximum value in the same period of time. This maximum value is substantially the same as that attained after one hour at 150° C. After several weeks the coercive force decreases somewhat as a consequence of the slow coagulation of the iron nitride. The remanence increases during tempering but does not attain its initial value.

The separate and distinct effects of the nitride and of the cementite are clearly brought out by the tempering curves of the mild steel. The 3 curves experience somewhat of a lag after about half a week tempering which persists up to about one week, after which a new increase sets in. This shows that the speed of the effect upon the physical properties is different in the different cases. The effect of the nitrogen has the upper hand in the first stages; its effect after half a week causes a maximum value in a manner corresponding to the results obtained with the electrolytic iron. Later the effect of the carbon is brought out, which effect extends over several weeks and which even after 12 weeks is far from completed. Characteristically this effect is accompanied by an increase of the remanence which was hardly noticeable during the separation of the nitrogen.

In order to get an idea as to the speed of reestablishment of the equilibrium during the cooling of nitrided iron, the following

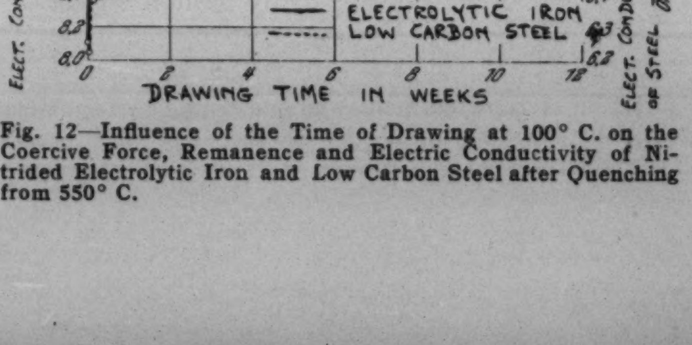

Fig. 12—Influence of the Time of Drawing at 100° C. on the Coercive Force, Remanence and Electric Conductivity of Nitrided Electrolytic Iron and Low Carbon Steel after Quenching from 550° C.

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[7] *Zeitschrift für Physik*, Vol. 54, 1929, pages 1–15.

test was made. A bar of nitrided electrolytic iron was heated to 400° C., cooled in the furnace to increasingly lower temperatures, and quenched. The rate of cooling was about 50° C. per hour. After each treatment the specimen was drawn for one hour at 150° C. in order to precipitate out as much as possible, the nitrogen remaining in solution. In this case the increase in the coercive force and the conductivity may be taken as a measure of the nitrogen contained in solution after the cooling. Table V shows that the change is the smaller the more slowly and the lower the steel has been cooled. The change of the various properties may be determined directly from an inspection of the prior treatment. It is seen that the cooling rate has to be very slow from 400° C. downward, in order to precipitate the last particles of the nitrogen. It is to be noted that in these tests the remanence increases as rapidly as the coercive force, whereas, in the above described tests the nitrogen precipitation was without any essential effect upon the remanence.

Table V—Effect of the Cooling Rate Upon the Nitrogen Precipitation

Heat Treatment	Coercive Force gauss	Remanence gauss	Electric Conductivity $\frac{m}{ohm \cdot mm.^2}$
Quenched in water at 400° C.	3.0	7,400	8.62
and drawn at 150° C. for 1 hr.	7.2	10,000	8.76
Cooled in air at 400° C.	4.1	8.150	8.64
and drawn at 150° C. for 1 hr.	6.9	10,650	8.86
Cooled from 400–250° C. in the furnace and cooled in air	4.2	8,300	8.85
and drawn at 150° C. for 1 hr.	6.2	11,050	8.90
Cooled from 400–200° C. in furnace, then cooled in air	4.4	9,250	8.88
and drawn at 150° C. for 1 hr.	5.2	10,700	9.90
Cooled from 400–150° C. in furnace, then cooled in air	4.9	10,800	8.90
and drawn at 150° C. for 1 hr.	5.3	11,000	8.90
Cooled from 400–100° C. in furnace, then cooled in air	5.0	10,900	8.91
and drawn at 150° C. for 1 hr.	5.2	11,050	8.91

The Effect of Etching on Nitrided Iron

When etched with alcoholic nitric acid, the nitride needles appear as dark lines, provided they have not been polished very flat. In the latter case they are visible as broad plates having a yellow tint. This etching reagent is frequently unable to bring out small quantities of very finely divided nitrogen so that it may easily happen that the nitrogen is not observed at all. The nitrided eutectoid presents an appearance like pearlite and is undistinguishable therefrom.

A very good etching reagent for the nitrogen precipitations is A. Fry's copper solution for microscopic studies.[8] It colors the needles and the eutectoid a deep black and attacks the pearlite considerably slower than the nitrided particles. It is advantageous to treat a polished surface which has been etched with nitric acid with this copper solution.

A very sensitive reagent for nitrogen is a solution given by F. Comstock[9] containing mercury chloride and copper chloride. It colors the needles and the nitrided eutectoid fields dark without attacking the ferrite and cementite and, independently of the heat treatment of the steel, is very suitable for determining the nitrogen. Only the nitrided portions are attacked and the dark coloration increases with the nitrogen concentration.

Fry's etching reagent has also been found to be very suitable for macroscopic studies since nitrided zones are colored considerably by this reagent. However, as has been pointed out for carbon, the results depend upon the condition of the nitrogen.[10] There will be no coloration if the nitrogen is contained in solid solution in alpha iron, but a very pronounced coloration if the nitrogen is precipitated out. The intensity of the indication also depends upon the degree of dispersion of the precipitation.

Résumé

Due to an increasing solubility of nitrogen in alpha iron with increasing temperature, the properties of iron nitrogen alloys may be affected considerably by heat treating them below the temperature corresponding to their eutectoid transformation. These effects have been studied with electrolytic iron and mild steel. The working properties of the alloys deteriorate by the transformation of the nitride precipitations into a supersaturated solid solution, and are entirely destroyed if the nitrogen is sufficiently concentrated. The supersaturated solid solution of nitrogen in alpha iron, if aged at room temperature, experiences a duralumin type of hardening. By precipitating the nitrogen out of the supersaturated solid solution, the working properties may be restored. If drawn for one hour, this occurs at 150° C.

The state of the nitrogen is decisive for the magnetic properties of the alloys. The coercive force in particular is increased considerably by the very fine nitride precipitation which takes place during cooling below about 300° C. by the decomposition of the supersaturated solid solution. In nitrided mild steel the effect of the nitride precipitation is superposed to that of the cementite separation.

Magnetic and electric measurements reveal the fact that the solubility of nitrogen in iron increases between 100 and 150° C. The tendency of the iron nitride to coagulate is apparently very small.

The Fry etching reagents are particularly suitable for the determination of nitrogen and the state of its occurrence.

The temperature of the A_1 point is reduced by the presence of nitrogen in the pearlite.

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[8] *Stahl und Eisen*, Vol. 41, 1921, pages 1093–1097.

[9] *Transactions American Institute Mining & Metallurgical Engineers*, Vol. 67, 1922, page 306.

[10] W. KÖSTER, *Archiv für Eisenhüttenwesen*, Vol. 2, 1928–1929, pages 503–522.

Mellon Institute Director Announces Plans for New Building

Dr. Edward R. Weidlein, Director, Mellon Institute of Industrial Research, Pittsburgh, Pa., has announced, speaking for the Board of Trustees, that the institution is to increase its facilities for serving American industries by a building project that will enable the material expansion of all its research activities. Detailed plans are now being prepared by the architects, Janssen and Cocken, of Pittsburgh, and construction will begin as soon as the drawings are completed, early this fall. The Mellon-Stuart Company, also of Pittsburgh, is the general contractor.

The building, which is to occupy the site of the Institute's Building No. 2, is designed on classical lines, a plain, simple, but massive structure, surrounded by columns. It will provide ample space for housing many more Industrial Fellowships than the 63 that now tax the Institute's facilities to the utmost. The other departments of the institution will be increased in proportion.

When the present home of the Institue was completed, in 1915, it was felt that the Industrial Fellowship procedure created by Robert Kennedy Duncan had passed from the experimental to the practical stage. The building, which was given to the institution by Andrew W. and Richard B. Mellon, incorporated the best laboratory constructional features of that period. It was thought then that it would provide adequate space for growth for many years; but for practically 10 years the Institute has had a waiting list of companies, often almost as long as the roster of companies whose problems were being investigated. Even the additional space afforded by Building No. 2, acquired in 1927, gave but temporary relief from the need for more laboratories arising from proposed new investigations and from the necessity of increasing the personnel of fellowships already in operation.

In addition to providing a greatly increased number of laboratories, the new building will give more commodious quarters for the general departments. The present library contains 11,000 volumes; the new library is planned to accommodate 250,000 volumes. The present Department of Research in Pure Chemistry will be expanded and facilities for pure research in other branches of science will be provided. Much more elaborate chemical engineering laboratories are to be available in the new building, and also the fellowships in each specific field of industrial research are to be grouped in suites of rooms so that they can best make use of general apparatus adapted to their needs. Certain rooms will be equipped for specialized phases of experimental technique, such as electrochemistry, spectroscopy, low-temperature studies, radiations, high-pressure experimentation, etc. Other special features to be included are a large lecture hall, a dining hall, an industrial fellowship museum, and an underground garage. For the past five years members of the Institute's Executive Staff have been visiting important laboratories in America and Europe to obtain information on new features in design and equipment.

The new laboratory structure will be of that type of classical Greek architecture known as Ionic. It is to be seven stories high, with monolithic columns along all four sides. The proportions will be approximately 300 feet by 400 feet. The main entrance, which is located on the third floor, is reached by steps extending along the entire front of the building. The laboratories are to face on interior courts. The design of the new building is to be such that additional laboratory suites can be constructed in the interior courts without marring the beauty of the general appearance and without interfering in any way with the original laboratory units.

Book Reviews

Bearings and Bearing Metals. By W. M. Corse. American Chemical Society Monograph Series, No. 53. Chemical Catalog Company, Inc., New York, 1930. Cloth, 6 × 9 inches, 383 pages. Price, $7.00.

This is a grown-up bibliography. Some 40 pages are devoted to a concise discussion of the history of bearings, the essential properties of bearing metals, and the problem of lubrication. (Only sleeve or sliding-contact bearings are dealt with, ball and roller bearings being outside the scope of the work. Hence, it deals only with non-ferrous alloys.)

Then follow references to some 1300 articles through 1928 on bearing metals, bearings, friction and lubrication. Beside the original reference for those articles which have been abstracted in Chemical Abstracts, the abstract section of the British Journal of the Institute of Metals, or from which data have been incorporated in the International Critical Tables, the abstract reference is given.

In the next section, thoughtful, detailed abstracts are given of 234 of these papers, so chosen as to bring out the facts and theories that have developed in the last 40 years' study of bearings. These abstracts are much more complete than those ordinarily found in routine abstracts.

Quantitative data on the properties of bearing metals are collected into tables at the end of the book, and there is a subject and author index.

The book is a little different from many of those in the monograph series in that it depicts the state of the art on the subject dealt with, largely through the statements of others rather than from the point of view of one man.

Corse's wide experience in making and studying bearings is evident throughout, but he is not dogmatic, and leaves the reader to form his own conclusions from the assembled information.

As a matter of fact, no other method could be used, and produce as useful a book. Too little is known about the fundamental facts in regard to why bearing metals are bearing metals for anyone to be dogmatic in a scientific discussion of the subject.

The book will be useful to a wide circle of readers. The non-ferrous metallurgist, the non-ferrous analyst, engineers having to do with bearings and lubrication, and the physicist interested in theories of lubrication will all find it of much value.—H. W. G.

Annual Survey of American Chemistry. Vol. IV, July 1, 1928 to Dec. 31, 1929. Edited by C. J. West. Published for National Research Council by Chemical Catalog Company, Inc., New York, 1930. Cloth, 53 sections, 549 pages. Price, $4.00.

The sections of direct metallurgical interest cover about 30 pages, and are: Determination of Crystal Structure by X-rays, W. P. Davey; X-ray Examination of Materials, G. L. Clark; Chromium, W. Blum; Iron and Steel Metallurgy, C. H. Herty, Jr.; Nickel, P. D. Merica and M. Wing.

In the whole book, publications by some 2,500 different authors are mentioned, and references given. Comment on any one topic is necessarily very sketchy. The main value of the book will be in drawing the attention of the reader to publications on some topics he may otherwise have missed. It is a sort of "finding list" to publications picked out by experts as representing new and important information.

It seems odd that there is no section on corrosion and its prevention.—H. W. G.

Das Betriebslaboratorium der Metallgiessereien und verwandter Betriebe. By W. Claus. Wilhelm Knapp, Halle (Saale), Germany, 1929. Cloth, $6^{1}/_{2} \times 9^{3}/_{4}$ inches, 88 pages, 154 figs. Price, 7.20 R. M.

Part 9 of the series on iron, steel and non-ferrous foundry practice, edited by Hubert Hermanns.

Claus in his book gives an outline of the principles and methods of testing materials as well as a survey on instruments and equipment for plant laboratories. He considers physical testing methods and machines, X-ray equipment, chemical, physical and metallographic testing. Most of the 154 figs. illustrate testing equipment and instruments. A list of text-books, reference books and periodicals, which the library of a testing laboratory should contain, is given.

In spite of the brief representation, the subject can be considered as being well covered. Metallurgists who must equip plant testing laboratories will find valuable information, though the book generally deals only with German practice.—G. Neuendorff.

Deformations permanentes et ruptures des aciers. Les causes prevenues. Les accidents. Paul Regnauld. Dunod, Paris, 1929. 8 × 10 inches, 90 pages, 31 figs. Price, 23.30 Fr.

When one has an opportunity of extending the testing of materials into the realm of speeds and stresses existing in artillery practice, the usual conceptions of the behavior of metals are liable to receive an illumination and interpretation not always agreeing with the universally adopted viewpoint. Mr. Regnauld, chief engineer of the French naval artillery, was in intimate contact with problems of this character, and the results of his observations and conclusions given in the present little volume open an exceedingly interesting field of conceptions connected with the interpretation of the mechanism of the failure of materials subjected to different types of stresses. The deformation occurring at the speeds of modern projectiles exaggerates certain features of the phenomena of fracture, otherwise entirely escaping the proper recording. Once observed they did indicate a path toward modifications of the usual testing methods which would bring them to light. The author was fortunate in the devising of his test methods, and with their use he succeeded in a clear demonstration of the influence of several variables usually either entirely omitted from consideration or treated but superficially. In reality they exert a much stronger influence than it is generally considered. The original purpose of the book, demonstration of the influence of strains existing in metals on their physical properties and their suitability as a construction material, is much extended covering among other factors the influence of the heat generated in fracture and the effect of the mass of specimens on the results of mechanical testing. The treatment of the subject is both original and well founded on facts. The literature is adequately consulted and the references are brought fully up to date, though there seems to be but little need in quoting theoretical considerations advanced by metallurgists more than a quarter of a century ago. Numerical data are complete and the experimental procedure is fully described. It appears, however, that on a few occasions a larger number of parallel tests might considerably strengthen the deductions derived from them. —John D. Gat.

Directory, Index and Buyers Guide of Wire and Wire Products. Quinn-Brown Publishing Corp., New York, N. Y., 1930. Cloth, 6 × 9 inches, 116 pages. Price, $5.00.

This is the third edition of this annual directory, index and buyers' guide of wire and wire products.—R. R.

X-Ray Technology. By H. M. Terrill & C. T. Ulrey. D. van Nostrand Co., Inc., 1930. Cloth, $6 \times 9^{1}/_{4}$ inches, 256 pages, 143 figs. Price, $4.50.

X-rays are now used for so many purposes that "X-ray Technology" may be expected to be of interest to scientists in widely different fields. Particular attention has been given to the quantitative measurements involved in X-ray therapy and in industrial applications but most of the material presented is of interest to all who are engaged in the production, measurement or utilization of X-rays.

Much of the contents of the book may be classified as X-ray engineering. Emphasis has been placed upon the practical rather than the theoretical aspects of X-ray measurements and considerable space has been devoted to the description of modern X-ray apparatus and the methods of using it. No mention is made of the various types of gas filled tubes that are still of utility for certain purposes, but the manufacture and operation of Coolidge X-ray tubes are treated in some detail. A chapter on the different types of high voltage generators used for X-ray work is followed by a description of the instruments and methods used to measure the current and voltage supplied to the X-ray tube. Succeeding chapters deal with ionization, total energy, wavelength, and biological measurements of X-rays. The concluding chapters discuss briefly the use of X-rays in radiography, and in the applications of X-ray spectroscopy and crystal structure analysis.

The book contains a number of practical suggestions with regard to the proper use of X-ray apparatus and should be a useful addition to any X-ray laboratory.—J. B. Friauf.

Steel Treating, a Booklist. Compiled by The Newark, New Jersey, Public Library. Paper, $3^{3}/_{8} \times 6$ inches, 16 pages. Price, 15 cents.

This valuable list is the answer to a request made by the New Jersey section of The American Society for Steel Treating and is based on a former list published by this Society in Cleveland.

The 155 books noted are on the approved list of The American Society for Steel Treating, and were selected for their interest and value to steel engineers. Subjects covered are: general problems; analytical chemistry; carburizing; cast iron and steel; corrosion; electric melting and plating; furnaces and fuels; handbooks; heat treatment and forging; metallography and metallurgy; physical properties and welding. There is also a list of 26 approved magazines and an author index. An added feature is the starring of the best books on each subject, thus forming a recommended first purchase list for individuals and small libraries.

The Librarian offers New Jersey engineers the use of the library's special technical service, the inter-library loan plan, engineering index of over 1700 technical journals, photostat and translation departments.—H. W. GILLETT.

The Journal of the Institute of Metals, 1929. No. 2, Vol. 42, published by the Institute, 36 Victoria Street, London, 1929. Cloth $5^{1}/_{2} \times 8^{1}/_{2}$ inches, 846 pages. Price, $7.75.

This volume of "Jim" contains the papers presented last fall at the Düsseldorf meeting of the Institute. Instead of being purely British as usual, the volume has quite an international flavor.

The outstanding paper of the volume is that on the Reduction of Shrinkage Cavities and Vacuum Melting, by Rohn of the Heraeus Vacuumschmelze. Masing of Siemens and Halske, and Rosenhain of the National Physical Laboratory contribute papers on methods of research in physical metallurgy and metallography. Chevenard, Portevin and Waché of France, Haas of Germany and Uno of Japan, gave papers on dilatometry, while Swiss and English authors deal with various subjects relating to aluminum, and a paper on oxide in copper came from Australia. Other papers deal with corrosion, electric melting, creep of Ni-Cr alloy, properties of arsenical copper and crystallization of gold.

As usual, the part that will be most used is the 300 pages of abstracts of the literature of non-ferrous metallurgy.

The volume is up to the usual high standard.—H. W. GILLETT.

Commercial Chromium Plating. By R. SCHNEIDEWIND. Circular Series No. 3, Department of Engineering Research, University of Michigan, Ann Arbor, Michigan, January, 1930. 60 pages. Price, $.50.

This circular, which tells both how and why, is written for the practical plater. It is the best job of putting scientific facts into easily understood English we have seen in a blue moon. The task of writing a practical manual is one that is seldom well accomplished by the scientist. This series is edited by J. R. Nelson, Professor of English. If the cooperation of the English Department will produce such a good product, we recommend that more scientists secure the help of experts in the writing of English. Lacking such aid, they might copy the style of this circular.

But the diagrams, which bring out salient facts so clearly, can hardly be ascribed to the editor, so we imagine that the editor had a pretty good manuscript on which to work.

There is no especial need to review the contents of the circular; it contains a summary of the outstanding facts in regard to chromium plating, with sufficient attention to the reasons why the facts are as they are to make it of as much use to the scientist as to the practical plater. One may have all the information in other publications, but even so, anyone interested in chromium plating will find the circular worth its price.—H. W. G.

Röntgenographische Werkstoffprüfung. By KARL BECKER. Friedrich Vieweg & Sohn, Braunschweig, 1929. Paper, $5^{1}/_{2} \times 8^{1}/_{2}$ inches, 100 pages, 76 figs. Price, 7 R. M.

X-ray testing of materials has increased in importance in recent years. X-rays soon will be an indispensable means for the testing of materials.

In a pleasant manner Becker shows what can be accomplished with the different X-ray methods, thus giving valuable practical information to the man who applies X-rays in his work.

The physical and crystallographic premises are outlined first, all known X-ray methods in detail and finally the application of the manifold methods for certain special investigations.

In the accompanying well-produced photographs the author endeavors to demonstrate the characteristics of various modifications of structure of metals so that research men who are less familiar with the evaluation of X-ray photographs may at least draw qualitative conclusions.—G. NEUENDORFF.

Die Eigenschaften des Hartmessings. By O. BAUER and K. MEMMLER. Julius Springer, Berlin, 1929. Paper, $8 \times 11^{1}/_{2}$ inches, 58 pages, 76 figs., 62 tables. Price, 13.50 R. M.

This is a very detailed description of mechanical tests carried out by the Staatliches Materialprüfungsamt and the Kaiser-Wilhelm-Institut für Metallforschung on hard brass or screw brass designated Ms 58 according to the proposals of the Standards Committee sponsored by the German Industries. Material was supplied by 5 different (unnamed) firms chiefly in the form of round extruded rod, the same subsequently straightened in a machine using conical rolls, or drawn and then straightened although some hexagonal rod was tested and a number of laboratory heat treatments were undertaken in order to extend the scope of the tests.

The different materials, all precisely characterized as to chemical composition, mechanical and heat treatment, contained from 57.43–60.17% copper, 0.58–2.50 lead, 0.08–0.47 iron, in most cases about 0.4 tin together with a few hundredths of a percent of nickel, and in one case very small quantities of aluminum, manganese and arsenic.

In addition to the ordinary tension test including the determinations of stress-strain with the Martens mirror apparatus, compression, Brinell, impact, reversed impact, shearing and torsion tests are reported. An especially interesting feature of the work was the application of the Heyn-Bauer-Sachs method of determining the distribution of internal strain (by removing successive layers of material and measuring the resulting length changes) to all of the round rod stock in the various conditions supplied and also after relief annealing at various temperatures up to 400° C.

Some of the tension tests were made at temperatures up to 500° C. It was found that somewhat above the melting point of lead the rods lost two-thirds of their strength but more than doubled their ductility (percentage elongation in 10 cm.).

Many micrographs are included and it is maintained that the lead, although it cannot be seen clearly in rod which has been extruded, drawn and straightened, is present as elementary lead, probably in the form of thin membranes.

It is not possible to furnish a satisfactory summary in brief form of the results of these elaborate tests but the principal conclusions drawn from the very interesting section of the work devoted to internal strain are as follows:

(1) Extruded and drawn material shows according to the amount of drawing tension stress in greater or lesser degree in the outer zone and a transition through a neutral zone to compression stress in the interior of the rod.

(2) Extruded, drawn and straightened rod shows substantially decreased tension stress in the outer zone with the neutral zone shifted somewhat towards the center.

(3) Annealing at a temperature as low as 200° C. decreases the tension stress in the outer layers to approximately one-third and annealing at 400° C. to one-tenth of its initial value.

(4) Rod which has been straightened after extrusion (without drawing) shows moderate compression stress in outer fibers with transition through neutral zone into a condition of tension stress.

(5) Annealing the above material at 300° C. effectively decreases the stress and after treatment at 400° C. the compression stress in the outer layer is hardly discernible.

(6) There are two ways to decrease or eventually remove the stresses in cold worked material, viz.,

(*a*) By annealing at temperatures upward of 250–300° C.

(*b*) By cold rolling a previous cold drawn material or cold drawing a previously cold rolled material.—C. H. MATHEWSON.

Röntgenographie der Metalle und ihrer Legierungen. By M. C. NEUBURGER. Ferdinand Enke, Stüttgart, Germany, 1929. Paper $6^{1}/_{2} \times 10$ inches, 278 pages, 66 figs., 110 tables. Price, 25 R. M.

This book is a supplement to "Röntgenographie des Eisens und seiner Legierungen" by the same author which was reviewed in METALS & ALLOYS, Dec. 1929, page 302.

It can be stated that it is the most comprehensive and the first complete reference book on the subject. It contains a complete record on the present known X-ray investigations of non-ferrous metals and alloys. The results are presented and discussed on the first 221 pages of the book. Tabulation of data, classified by the various types of lattice and an alphabetic tabulation follow. A bibliographic index will help in the quest for the original investigations.

Metallurgists whose work is devoted to this subject will find in this book a very useful time-saving instrument. G. NEUENDORFF.

A Chemical Dictionary, Containing the Words Generally Used in Chemistry, and Many of the Terms Used in the Related Sciences of Physics, Astrophysics, Mineralogy, Pharmacy and Biology with Their Pronunciations. Based on Recent Chemical Literature. By INGO W. D. HACKH. P. Blakiston's Son & Company, Philadelphia, 1929. Cloth, 7 × 10 inches, 790 pages. Price, $10.00.

In the literature of chemistry in the English tongue, the word "dictionary" is something of a misnomer. Through the excellence and the widespread use of the works which have preempted the field, the term has come to connote a work of cyclopedic character.

The recent book by Hackh is not a cyclopedia, but it is a dictionary in every true sense of the word—it has the form of a dictionary and it has the content and quality of a Dictionary with a capital D!

Considering the scope, and the detail, it is not a large book. It has been made with a utilitarian purpose which contrasts favorably with the frequent attempts to produce an imposing book through the expedients of padding and expansion. Compactness, which is a desideratum in any dictionary has been achieved through concise definition, and intelligent attention to arrangement of material.

This arrangement is similar to that of some of our best medical dictionaries. For example, under *sodium*, this dictionary gives the essential information regarding character and uses; then, without repetition of the parent substance, it lists virtually in a single paragraph the compounds from *s. abietinate* to *s. zincate*. Separate paragraphing of the individual terms (the usual dictionary arrangement) would have required several times the present space with no resulting advantage, since the use of bold-face type makes the alphabetization readily apparent. It should be said that the publisher has had no small part in the excellence of the presentation.

In all walks of life there is a regretable lack of knowledge regarding the proper use of dictionaries and the service afforded by the good ones. Young people and adults argue about the spelling, pronunciation or derivation of a word, and attempt to settle the matter by writing to a newspaper! The use of the few important dictionaries of the English language should be taught in school (or, failing that, in college). Hackh's dictionary should form part of the teaching equipment of every instructor of chemistry. The beginner in chemical work who requires orientation in the various branches of the profession will find under "Chemistry" more subdivisions of the subject than he knew existed.

Derivation of words is not included, but pronunciation is indicated, a simple key, avoiding diacritical marks, appearing on every page.

There are some omissions, of course. These will be detected with some sense of elation, because the approach to exhaustiveness constitutes a challenge to find something which has been overlooked. The remarkable thing, however, is that a first edition of any dictionary covering so broad and intricate a field should be so nearly complete. It contains many terms which have found their way into general dictionaries only very recently, if at all, and includes some (such as "balopticon" and "klydonograph") from the borderland of chemistry.

The dictionary includes the names of many chemists (living and dead) with very brief notes regarding their achievements, and with occasional portraits. This feature probably presented one of the most difficult problems of compilation, but the results, as regards contemporaries, is a little bewildering. The reviewer ventures the prediction that many a user of the book while searching for something else will run across the name of Bill Jones, able-bodied chemist, and will thereupon promptly look for his own name, probably to be disappointed.

Brief use and somewhat superficial examination would indicate that it deals more fully with pharmacy and botany than with some of the other allied branches of science. It does not, of course, attempt to cover all of metallurgy, so there will still be use for H. P. Tiemann's "Iron and Steel."[1] Within the field of chemistry itself it does not attempt the inclusion of commercial information regarding containers, fire hazard and shipping regulations such as is given briefly in the "Condensed Chemical Dictionary."[2]

In announcements of this dictionary, attention has been called to the statement in "Crane and Patterson"[3] that "There has been in modern times no adequate general dictionary or wordbook of chemistry . . ." The claim is that this gap in the literature has now been filled by Hackh's "Chemical Dictionary." To a very material extent, this is true. It is a very useful book, at present without a rival.—E. H. MCCLELLAND.

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[1] McGraw-Hill Book Company, New York, 1919.

[2] Chemical Catalog Company, Inc., New York. 1919. Second Edition, 1930.

[3] "Guide to the Literature of Chemistry," by E. J. Crane and Austin M. Patterson. John Wiley and Sons, New York, 1927.

Analyse des Metaux pas Electrolyte. By A. HOLLARD & L. BERTIAUX. 4th Edition. Dunod, Paris, 1930. Paper, $6^1/_2$ × 10 inches, 232 pages, 28 figs. Price, 62.50 Fr.

The first nine chapters (50 pages) of the book deal with the theoretical principles of electro-analysis, with the classification of the metals and with the general methods of their separation. Three chapters (55 pages) describe the practical modus operandi of the determination of metals such as manganese, zinc, iron, nickel, cobalt, cadmium, tin, lead, copper, arsenic, bismuth, antimony, silver, gold and platinum. Ten chapters (180 pages) relate to the analysis of industrial alloys of the elements mentioned and of their minerals. The rapid electro-analysis by means of a rotary anode is discussed in a special chapter. The book contains a considerable number of numerical examples of application and contains numerous illustrations of apparatus and circuits described. It should prove a very valuable text-book for use in industrial laboratories.—A. J. MICHEL.

Calorimetry Issue of Instruments. Instruments Publishing Co., Pittsburgh, Pa., Feb. 1930. Paper, 6 × 9 inches, 128 pages. Price, 50 cents.

The February issue of *Instruments* is devoted almost entirely to Calorimetry in all its branches. When one issue of a magazine contains articles by such eminent authorities as Professor S. W. Parr, W. E. Stackhouse, Dr. Walter Block, and describes in detail calorimeters from the industrial steam calorimeter down to a micro calorimeter, such an issue of a magazine can almost be called a book on calorimetry. There are some sixty odd pages of this number devoted exclusively to the design, construction and use of calorimeters. Coal Calorimeters, Gas, Steam, Recording Gas, Oxygen Bomb, Peroxide Bomb, Adibatic, Micro, Hand Calorimeters, Bomb Calorimeters and B. t. u. Indicators are all described quite fully from both scientific and industrial viewpoints. The descriptions of the individual instruments will give the reader a very broad, intimate knowledge of the design, construction and use of the various calorimeters described so that he will be in a position to select from all the calorimeters available on the market, that one most suited to his particular needs. This one number of the magazine is a virtual handbook on calorimeters. It is hoped that future numbers will cover subjects like Physical Testing of Metals, Thermal and Electrical Conductivity, Magnetism and similar subjects in the same thorough manner.—A. SCHROEDER.

Gmelin's Handbuch der anorganische Chemie. 8th edition. Eisen. Verlag Chemie, Berlin, 1929. Paper, $6^3/_4$ × 10 inches. Part A (1) 224 pages. Price, 33 R. M. Part A (2) 87 pages. Price, 10.50 R. M. Part B (1) 312 pages. Price, 46 R. M.

For many years German metallurgists have looked forward to the volume on iron of the new Gmelin. Gmelin's handbook was always recognized as the most comprehensive and reliable among all chemical handbooks. In consequence of the tremendous progress in all sciences the pre-war Gmelin showed "aging effects" and it can easily be appreciated that many a research worker desired the "reaction velocity" of the new publication speeded up.

The first three parts are now published. Those who have occasion to look over these parts will find that the aim of the "Deutsche Chemische Gesellschaft" to give a comprehensive and reliable handbook on iron has been accomplished in a very excellent manner. One might wonder if there will be, apart from the metallurgical processes, any information which a man who works with iron cannot find. An enlargement of the scope of the volume on iron has been carried out to make it of greater value, also to the metallurgist.

Part A (1) gives a valuable historical outline of ferrous metallurgy, describes geology and mineralogy of iron ores, including brief statistics on ore deposits and ore consumption the world over. Then follows the production of pure iron by different electrolytic and chemical methods, concluding with the description of some special forms of iron (pyrophoric, colloidal, single crystals).

Part A (2) contains the complete record of the physical properties of pure iron, as atom structure, modifications, crystallographic, thermal, optical, magnetic and electrical properties. This part furthermore deals with electrochemical behavior.

Part B is devoted to iron compounds. B (1) deals with iron hydrogen, iron-oxygen, iron-nitrogen, iron-fluorine and iron-chlorine.

Such a work as Gmelin's Eisen can only be accomplished by the tireless efforts of experts in many fields. In all parts extensive bibliographical references to simplify the search for more detailed information are given.

Gmelin's Handbook of Inorganic Chemistry is a work which will be difficult to surpass.—G. NEUENDORFF.

Röntgenspektroskopie und Kristallstrukturanalyse. By Dr. Arthur Schleede & Dr. Erich Schneider. Walter de Gruyter & Co., Berlin, 1929. Cloth, 6$^1/_2$ × 9$^1/_2$ inches. Vol. 1, 336 pages, 249 figs., 57 tables. Price 20 R. M. Vol. 2, 344 pages, 553 figs., 40 tables. Price, 24 R. M.

In these two volumes the authors endeavored to provide the chemist, the physical-chemist and the physicist with a tool, which would make it possible for him to quickly acquire the necessary information to solve special problems in the field of X-ray spectroscopy and crystal structure analysis. With this premise the theory and practice of X-ray spectroscopy are thoroughly discussed from the practical and theoretical points of view.

The first volume gives an introduction to the manipulation of spectroscopy, with special attention devoted to qualitative and quantitative spectro-analysis, also a summary on structure analysis, in so far as this is possible without special crystallographic knowledge. The second volume contains basic information on crystal structure, the diffraction of rays on lattices as well as a brief description of the method of structure analysis. The book concludes with a review of the structures investigated to date and a discussion of the possibilities of chemical crystallography.

The specialist will find these two volumes extremely valuable due to the very complete bibliography; the technician is assured of a vast amount of useful practical kinks and experiences. The books have very little value for beginners.—Richard Rimbach.

Research Bulletin, "Rolled Zinc." Staff of Metal Section, Research Division, New Jersey Zinc Company, 160 Front Street, New York City, October, 1929, 54 pages; well indexed. Free.

This is a useful pamphlet to have in one's library whether one happens to have use for rolled zinc or not. Anyone dealing with sheet metal will find the description of the "temperscope" and of the cold bend test used by the New Jersey Zinc Company laboratories, of interest.

The fundamental properties of zinc are recorded, and its metallography, polishing and etching described. Some of the idiosyncrasies of zinc are its change of properties at about 70° F., brittleness increasing below that, and ductility above it so that very slight warming enables forming operations to be done that otherwise could not be. In ordinary cold-working, the metal is self-annealing. The rate of loading is very important. The presence of 0.005% tin as impurity so embrittles zinc that it cannot be rolled. Zinc is stronger across the direction of rolling than with it.

The bulletin is quite up to date, and is representative of the compilations of useful basic information on the properties of a product that are nowadays supplementing if not replacing the sales literature of the older type. Some data are given on spectroscopically pure zinc, but in general, the data relate to ordinary high grade zinc. The properties of the lower grades such as Prime Western are often separately discussed, but no mention is made of those points on which the properties of the still purer electrolytic zinc grades vary from those of high grade zinc. It is to be hoped that a future edition will give at least as much attention to electrolytic as to Prime Western.—H. W. Gillett.

Jahresbericht der Chemisch-Technischen Reichsanstalt 1928. Verlag Chemie, Berlin, 1929. Paper, 9$^1/_4$ × 6$^1/_4$ inches, 275 pages, 121 figs., 6 tables. Price, 24 R. M.

This preliminary condensed annual report briefly gives the results of investigations into the following subjects: metal chemistry, corrosion resistance, protective metal coatings and metallographical investigations of metals and alloys.

The report on metal chemistry is a contribution to the literature of the mechanism of electrolytic metal deposition, and specifically deals with the phenomena and conditions encountered during the passage of the current through the electrolyte. This report is not intended to be a detailed discussion of these phenomena but states that a more detailed and complete report is planned for future publication.

The report on corrosion resistance discloses data on the causes of corrosion and the resistance to corrosion of various industrial compositions and apparatus made of metals such as aluminum, zinc, phosphor bronze, brass and lead; the effect of hydrogen oxide upon aluminum and aluminum alloys; a practical method for rapidly testing the corrosion resistance of iron and steel; an investigation into the mechanism of the protective properties of red lead.

The report on protective metal coating deals briefly with practical scientific methods of testing paints and varnishes.

The metallographical report includes the result of routine investigations into the causes of failures of various machine parts and contains rather little information of interest to an experienced metallographist.—A. J. Michel.

Pickling of Iron and Steel. By Wallace G. Imhoff. Penton Publishing Co., Cleveland, 1929. Cloth 6 × 9 inches, 195 pages, 46 figs., 23 tables. Price, $5.00.

The extensive scope of this book covers pickling practice as applied to a wide variety of iron and steel products preparatory to galvanizing, tinning, enameling, etc. The principles of the process are presented in a manner designed to appeal to plant men; much of the material has been assembled from a series of journal articles recently written by the author. Detailed information as to the construction of vats, equipment for handling materials, heating, ventilating and drainage systems is included. The causes and prevention of numerous operating difficulties are discussed. Some attention is given to continuous pickling, grease removal, sand blasting and other special methods.

An important section is the 35-page bibliography on pickling originally compiled by the Carnegie Library of Pittsburgh and revised to the beginning of 1929 by Mr. Victor S. Polansky.

Owing to the varied practice for different materials there is necessarily some repetition; the index is a rather satisfactory guide to widely scattered information. The use of more graphs to illustrate the influence of temperature, acidity, and inhibitor content on metal loss, acid consumption, and rate of pickling would be welcomed by many readers. The chapter on inhibitors contains generalities chiefly of interest to the operator making his own comparative tests. The pickling of alloy steel and the disposal of spent pickle liquor are subjects which might have been discussed more fully.

The book should stimulate interest in pickling, and aid in raising the standards of current practice.—G. L. Frear.

Die Wärmebehandlung des Stahles. By O. G. Styrie. Walter de Gruyter & Co., Berlin, 1929. Cloth, 4 × 6$^1/_4$ inches, 119 pages, 58 figs., 14 tables. Price, 1.80 RM.

The book is one of the small Goeschen volumes and deals with the heat treatment of different steels, dividing them into steels for tools and steels for building purposes.

The author gives the Iron-Carbon diagram and explains the formation of martensite, troostite, sorbite and pearlite in microphotographs.

He also writes of the origin of stresses and cracks and gives a short description of the influence of adding a small percentage of elements, such as chromium, vanadium, nickel, tungsten, etc.

Different furnaces are mentioned and quite a little is said about electric ovens. The data on salt and lead baths is also interesting. Sketches of heating and cooling curves of different materials are shown. Very little is said about tungsten carbide tools and it is very surprising that Nitralloy steel and the hardening of it in an ammonia atmosphere is not mentioned at all.

In general the book may be taken as a short description of heat treatment of steel and it would certainly be a help to the student as well as the practical man.—F. J. Tobias.

Dynamische und statische Zugversuche an Aluminium-Einkristallen. By J. Weerts. VDI-Verlag, Berlin, 1929. Paper, 8 × 11$^1/_2$ inches, 20 pages, 30 figs., 3 tables. Price, 4 RM.

Weerts has conducted a very careful and extensive series of dynamic and static tensile tests on aluminum single crystal and polycrystalline material. The manuscript is a complete description of the experimental apparatus, methods of calculation and correlation of results.

Single crystals were prepared by the familiar "straining and annealing" experiments and the orientation determined by the isotropic reflections of polarized light from cubic etching pits.

It was found that by plotting the relation between the cubic axes and rod axis on a stereographic projection that none of the 27 crystals had the same original orientation.

Measurements of crystal orientation after dynamic and static tests confirmed the work of Taylor and Elam that aluminum single crystals plastically deform by slipping on $\{111\}$ planes in a $\{110\}$ direction with a simultaneous rotation of the crystal lattice about the tension axis. Slip movements occur in the direction $\{110\}$ in which the thrust-stress component is the largest.

Tensile strength—elongation curves deviated considerably for the different crystals which undoubtedly can be attributed to a variation in original orientation.

The crystals whose rod axes approached a $\{111\}$ direction were found to have the highest tensile strength while crystals whose axes approximated a $\{110\}$ direction had the greatest thrust-stress resistance. There was no apparent relationship between elongation and crystal orientation.

Single crystals which were fractured by dynamic stresses were found to have tensile strengths about 4$^1/_2$% higher than crystals under static load. In polycrystalline material this difference was increased to 5$^1/_2$%.

Some interesting speculations in regard to the nature of the mechanism of the plastic deformation of aluminum single crystals can be deduced from the results of Weerts' interesting presentation of the investigation.—K. van Horn.

Metallniederschläge und Metallfarbungen. By F. MICHEL. Julius Springer, Berlin, 1929. Paper, 280 pages, 13 figs. Price, 6.90 R. M.

The sub-title of this book describes it as containing practical instructions on the plating and coloring of ornamental and other metalware. Some 6 or 7 pages are devoted to elementary chemistry and electrical theory respectively, followed by sections dealing with primary cells, storage batteries, generators and miscellaneous and auxiliary electrical appliances. The preparation of articles for plating is then described including various cleaning baths and variations of the cleaning process to suit different metals and alloys. A further few pages are allocated to "general rules."

After this fairly detailed preliminary the deposition of the individual metals and alloys is dealt with. Cu, brass, Ag, Au, Ni, Co, Pt, Pd, Zn, Sn, Pb, As, Sb and Mo are in turn commented on at some length, in most cases the composition of the baths being given with the requirements for successful working.

Some 10 pages are then devoted to electro-typing, general discussion being followed by an account of the preparation of the "negative" or mold and the compositions of Cu, Ag, Au and Fe baths. This part of the book is concluded with notes on the deposition of metals by other than electrolytic methods.

The second part of the book which is much shorter—only 20 pages—describes the various methods of coloring metals by the use of chemical solutions, etc. The compositions of the solutions and, where necessary, explicit instructions for making them are given.—RICHARD RIMBACH.

The Manufacture of Chilled Iron Rolls. By A. ALLISON. Isaac Pitman & Sons, Ltd., London, 1929. Cloth, $5^{1}/_{2} \times 8/^{1}_{2}$ inches, 112 pages, 23 figs. Price, $2.50.

To the reviewer's knowledge this is the first book on the subject. The author is to be congratulated for this excellent and useful guide to the student which at the same time contains much information for the experienced metallurgist interested in controlling the solidification of molten cast iron.

The appearance of a book on this subject is unexpected as roll manufacturers still are conservative as regards the publication of information on roll production. The book will be welcomed by every American roll producer, though he will discover the undeniable conservatism of the English maker.

Following an historical introduction, cupola melting, oil fired air furnace melting and a combination of the two are considered. Detailed information on composition, metal mixtures, casting temperatures, metallurgical and casting operations as well as valuable data on chill tests, microscopic and mechanical tests are included.

The American producer will question some of the practices of alloy chill roll manufacturer. Every roll-maker who reads the book will be encouraged to undertake further research, the more so since the manufacture of complicated chilled rolls has not yet found a satisfactory practical solution.—G. NEUENDORFF.

Hütte, Taschenbuch für Stoffkunde. Wilhelm Ernst & Sohn, Berlin, 1926. Cloth, $5^{1}/_{2} \times 7^{1}/_{4}$ inches, 1173 pages, 356 figs. Price, 25.80 R. M.

It is always a gamble to publish a reference book which covers such a wide field, as a large number of collaborators must write the various articles. In the case of this comprehensive reference book on all engineering materials this difficulty is not completely overcome.

The articles are in part so detailed that even an expert can find valuable information. This may be a disadvantage in so far as the aim of the book is to give reliable information to every engineer. Not a few of the many excellent articles are too highly technical for the average operating man. To fulfill its purpose the book should be condensed and the arrangement of the material improved.

The four principal chapter headings are chemistry, testing materials, inorganic materials, organic materials. In the first chapter the principles of chemistry are reviewed, the second chapter deals with the methods of metal testing, metallography, chemical analysis, magnetic tests, electric resistance of metals, testing of insulating materials. The third chapter covers inorganic materials in three principal groups, metals, non-metals and minerals and ceramic materials. The final chapter is devoted to organic substances and deals in three groups with plant materials, animal materials, and fossil plant and animal materials.

The scope of the book is very wide and really covers all engineering materials. It is not necessary to mention especially that the book is written and edited in the thorough manner of German handbooks.—G. NEUENDORFF.

Reviews of Manufacturers' Literature

In this department we shall list each month a selection of the catalogs, books, treatises and other printed matter issued by manufacturers which, in our judgment should be of interest to the readers of METALS & ALLOYS. *Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter for consideration by the editor of this department are invited to do so, and it is suggested that* METALS & ALLOYS *be placed on the regular mailing list so that advance copies of any material of interest to the metallurgical field may automatically come to this department*—EDITOR.

Crucible Furnace Linings.—Leaflet describes a refractory block ring for lining crucible furnaces. Lava Crucible Co., Pittsburgh, Pa.

Abrasives.—Leaflet lists 15 claims pointing out advantages to be obtained by the use of American Steel abrasives. American Steel Abrasives Company, Galion, Ohio.

Silicon and Manganese "Pakets."—Leaflet lists claimed advantages for the use of silicon and manganese-silicon additions furnished in small briquet form. Paket Alloys, Inc., 100 East 42nd St., New York, N. Y.

General Catalog of Whiting Corporation. A 48-page booklet illustrates equipment for use in foundries, steel plants, power stations, railroad shops, chemical works and other industries. Catalog No. 175. Whiting Corp. Harvey, Ill.

Casting Cleaning. Folder illustrates new "hydro" core knockout, and also sand blast equipment. Pangborn Corporation, Hagerstown, Md.

Densite Refined Steels are described in detail with micro-photographs of various grades and conditions in a 28-page catalog. Refined Steel Products Co., Clark Building, Pittsburgh, Pa.

Industrial Furnaces. A 4-page leaflet outlining three reasons why they should be considered. These furnaces have temperature ranges up to 2500° F. Bellevue Industrial Furnace Co., 2971 Bellevue Avenue, Detroit, Michigan.

Remote Type Instruments. Catalog No. 7501 profusely illustrated photographically and with diagrams describes the Brown indicating and recording types. The Brown Instrument Company, Philadelphia, Pa.

Catalog No. 1114. The "Metallurscope" serves for microscopical examination of metal specimens in laboratories and workshops. Particular thought was given to its construction as will permit the instrument to be most complete for routine investigations. The instrument is probably the most compact device available for photo-micrography. The microscope can likewise be used for examination of larger specimens, etc. It serves excellently for Machine Shops, Factories, Foundries, Rolling-Mills, Wire Plants and in fact all metal industries who attach less value to current and far reaching research investigations and who can dispense with the large elaborate metallographic equipment. Being portable, the instrument can be taken from one plant to another. It has found extensive use in many laboratories. E. Leitz, Inc., 60 East 10th Street, New York, N. Y.

Udylite Process. An exposition of the theory and practice of the science and art of electrolytic application of cadmium—scientifically developed and perfected through a decade of careful experimentation. A 32-page illustrated catalog bound in filing folder. The Udylite Process Co., 3220 Bellevue Avenue, Detroit, Mich.

An Inspection Tour of Industrial Plants. A 12-page illustrated booklet showing Wilson-Maeulen's automatic temperature controllers in use. Wilson-Maeulen Co., 730 East 143rd Street, New York, N. Y.

Immersion Pyrometer. Bulletin No. 528 illustrates various models of the Pyro-Lance. Illinois Testing Laboratories, Inc., 141 West Austin Ave., Chicago, Ill.

Carborundum Refractories. Leaflet lists data on carborundum refractories. Carborundum Company, Perth Amboy, N. J.

Sand Control Equipment. Leaflet illustrates sand rammer and moisture indicator: permeability machine and sand strength machine; Federal Foundry Supply Co., Cleveland, Ohio.

X-ray and the Foundry. Bulletin discusses nature of X-rays and describes equipment. Kelley-Koett Mfg. Co., Inc., Covington, Kentucky.

Alloys for Use in Foundry Practice. Index of "Alpro" standard and special alloys for use in brass, aluminum and iron foundries. Alloys & Products, Inc., Oak Point Ave. and Barry St., New York, N. Y.

Cleaning Castings. Leaflet illustrates automatic star return tumbling barrel. N. Ransohoff, Inc., 5000 Spring Grove Ave., Cincinnati, Ohio.

Testing Sieves. Catalogue 53 entitled "The Profitable Use of Testing Sieves," includes information on various products of W. S. Tyler Co., Cleveland, Ohio.

Roto Portable Pneumatic Tools. Catalogue covers: grinders, buffers, sanders and drills. Rotor Air Tool Company, Cleveland, Ohio.

Material Handling. Bulletin F-101 describes material handling in the Semi-Steel Test Foundry Co. Northern Engineering Works, 210 Chene St., Detroit, Mich.

Sand Blast Rooms. Bulletin illustrates sand blast rooms for cleaning all types of work with either sand or steel abrasives. 16 pages. New Haven Sand Blast Company, New Haven, Conn.

Conveyors. A 52-page book contains engineering data and applications, as well as photographs of a large number of installations. Mathews Conveyor Co., Ellwood City, Pa.

Electric Hoists. Bulletin 503 gives installation drawings and details of electric hoists. Robbins & Myers, Inc., Springfield, Ohio.

Core Drying. Article in "Industrial Oven Notes" describes core drying at the Campbell, Wyant & Cannon Foundry Company. Young Brothers Company, Detroit, Mich.

Screens. A 38-page bulletin illustrates and describes Niagara positive complete rotating motion roller bearing screens. Niagara Concrete Mixer Co., 40 Pearl St., Buffalo, N. Y.

Exhaust Ventilating Fans and Blowers. Bulletin gives information, including dimensions and installation data for Charavay exhaust fans. Hartzell Propeller Fan Co., Piqua, Ohio.

Aluminum Alloys-Castings. A 24-page booklet gives information on aluminum alloy castings. British Aluminium Co., Ltd., 122 East 42nd Street, New York, N. Y.

Core Binder. Leaflet gives directions for using Glutrin in gray and malleable iron foundries. Robeson Process Co., 230 Park Ave., New York, N. Y.

Patent Department

Through an arrangement with Mr. W. M. Corse, Metallurgical Engineer, Washington, D. C., who operates a well-known Patent Information Service, we are able to publish every month a list of important patents in the metallurgical field from the United States, Canada and Europe. The following countries will be included in the European listing: England, Germany, France, Switzerland, Denmark, Norway, Sweden and Italy.

If our readers wish more information about any of the patents listed below they can get it by writing to our Patent Department, and mentioning the fact that they have the reference in Metals & Alloys. *We will be prepared to mail copies of United States Patents to clients within twenty-four hours of date of issue by special arrangement. Photostatic copies, translations of claims and of full text of foreign patents will be supplied if desired.*

This service is furnished under special arrangement with Mr. Corse's organization at most reasonable rates. Full information can be secured by writing to Patent Department, Metals & Alloys, *419 Fourth Avenue, New York.*

United States Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Bearing material for current-traversed bearings. J. A. Weiger, Union City, N. J., assignor, by mesne assignments, to P. R. Mallory Co., Inc., Indianapolis, Inc. No. 1,751,780. July, 9, 1927.

Process for the elimination of silicon in ferrophosphorus. H. E. White, Anniston, Ala., assignor to Federal Phosphorus Co., Birmingham, Ala. No. 1,751,783. Sept. 4, 1925.

Splicing mold. R. B. Guilbault, Culver City, Calif. No. 1,751,811. June 2, 1928.

Casting machine. A. L. Wilkes, Los Angeles, Calif. No. 1,751,846. Apr. 30, 1928.

Electric induction furnace process. A. E. Greene, Seattle, Wash. No. 1,751,856. March 25, 1921.

Method of brazing heating coils. A. T. Lewis and D. E. French, Merion, Pa., assignors to York Heating and Ventilating Corp., Philadelphia, Pa. No. 1,751,865. March 9, 1928.

Electric induction furnace. A. E. Greene, Seattle, Wash. No. 1,751,912. Jan. 3, 1913.

Electric furnace. A. E. Greene, Medina, Wash. No. 1,751,913. Feb. 8, 1927.

Mold. E. H. Traut, Detroit, Mich. No. 1,752,040. April 2, 1928.

Automatic mechanism for forming radiator cores and the like. V. Habif, S. Norwood, Ohio, assignor to The Ohio Automobile Radiator Co., Detroit, Mich. No. 1,752,077. Dec. 2, 1926.

Drop hammer. H. Beché, Huckeswagen, Germany. No. 1,752,141. Nov 10, 1926.

Non-corrosive alcoholic solutions (For inhibiting corrosion of iron). W. S. Calcott and H. W. Walker, Penns Grove, N. J., assignors to E. I. du Pont de Nemours & Co., Wilmington, Del. No. 1,752,145. Oct. 22, 1928.

Mechanism for forming and handling molds. E. Harmes, Wilkinsburg, Pa., assignor to New Process Multi-Castings Co. No. 1,752,175. Oct. 27, 1926.

Protection of metals (Protection against Hg by Pt-coating). S. Z. de Ferranti, assignor to Ferranti, Ltd., both of Hollinwood, England. No. 1,752,239. Feb. 10, 1925.

Method and apparatus for casting metal. E. S. Sawtelle, Cincinnati, Ohio assignor to The Sawbrook Steel Castings Co., Lockland, Ohio. No., 1,752,280. July 13, 1928.

Non-ferrous welding rod. A. R. Lytle, Flushing, N. Y., assignor to Union Carbide & Carbon Research Laboratories, Inc. Reissue Patent No. 17,631 (Original No. 1,716,590, filed Dec. 6, 1927). Feb. 19, 1930.

Apparatus for molding. C. D. Pettis, New York, N. Y. No. 1,752,308. Oct. 17, 1925.

Electrolysis of ferrous chloride. S. I. Levy, London, England. No. 1,752,348. Feb. 25, 1928; in Great Britain Feb. 10, 1928.

Process for reclaiming battery-plate material. W. C. Smith, Moylan, Pa., assignor to Primos Lead Co., Philadelphia, Pa. No. 1,752,356. Jan. 14, 1927.

Process of producing steel in an open-hearth furnace. R. Durrer, Berlin-Wannsee; F. C. Siemens, Berlin-Dahlem; and A. Sprenger, Berlin-Charlottenburg, Germany, assignors to Friedrich Siemens Akt.-Ges., Berlin, Germany. No. 1,752,374. Jan. 28, 1927; in Germany Sept. 26, 1925.

Rotary forging furnace. R. M. Hortvet, Minneapolis, Minn., assignor to Mahr Manufacturing Co., Minneapolis, Minn. No. 1,752,433. June 15, 1928.

Method of treating metals (Treating molten metal). C. H. Anderson, Oak Park, Ill., assignor to Western Electric Co., Inc., New York, N. Y. No. 1,752,474. Mar. 31, 1927.

Process for changing the properties of silicon steel. J. C. Karcher, Montclair N. J., assignor to Western Electric Co., Inc., New York, N. Y. No. 1,752,490. May 4, 1928. (Division of application filed Sept. 19, 1924, resulting in Patent No. 1,677,139.)

Checkerwork for furnaces. F. H. Loftus, Aliquippa, and T. N. Kurtz, Pittsburgh, Pa. No. 1,752,494. Jan. 31, 1929.

Sand-feeding mechanism for molding machines. E. O. Beardsley and W. F. Piper, Chicago, Ill., assignors to The Beardsley & Piper Co., Chicago, Ill. No. 1,752,549. Oct. 19, 1928.

Pin plate for molding flasks. C. H. Estes, Chicago, Heights, Ill., assignor to American Manganese Steel Co., Chicago, Ill. No. 1,752,552. Mar. 30, 1928.

Apparatus for heat-treating metals. H. D. Piper, Chicago, Ill., assignor to Western Electric Co., Inc., New York, N. Y. No. 1,752,573. Nov. 14, 1922, renewed July 28, 1927.

Electric welding. E. N. Jorgensen, Chicago, Ill., assignor to Western Electric Co., Inc., New York, N. Y. No. 1,752,598. Sept. 24, 1925.

Apparatus for annealing. H. M. Robertson, Cleveland, Ohio. No. 1,752,697. Oct. 22, 1927.

Mold wash. H. L. Braden, Youngstown, Ohio. No. 1,752,725. Aug. 3, 1927.

Composition for and process of cleaning metal. J. D. Klinger and C. L. Boyle, Detroit, Mich. No. 1,752,746. June 20, 1929.

Welding-rod coating. W. J. Hammers, Grand Rapid, Mich., assignor to Liverance & Van Antwerp, a Partnership, Grand Rapids, Mich. No. 1,752,793. Apr. 9, 1928.

Muffle furnace and method of operating the same. W. W. Kemp, Baltimore, Md., assignor to the C. M. Kemp Mfg. Co., Baltimore, Md. No. 1,752,800. Aug. 29, 1927.

Magnesium-covered calcium wire. W. A. Ruggles, Schenectady, N. Y. assignor to General Electric Co. No. 1,752,813. Jan. 9, 1926.

Guide for straightening rolls. G. A. Wise, assignor to Sutton Engineering Co., both of Pittsburgh, Pa. No. 1,752,825. Jan. 30, 1928.

Looping trough for rolling mills. J. R. George, Worcester, Mass., assignor, to Morgan Construction Company, both of Worcester, Mass. No. 1,752,841. Feb. 17, 1928. (Division of application filed May 16. 1925.)

Macrocrystal ingot and method of making it. (Refractory metal.) H. Alterthum, Berlin, Germany, assignor to General Electric Co. No. 1,752,877. July 6, 1922; in Germany July 13, 1921.

Induction furnace. George A. Chutter, Schenectady, N. Y., assignor to General Electric Co. No. 1,752,887. Apr. 13, 1928.

Molding flask. J. F. Hines, Lakewood, Ohio. No. 1,752,907. Jan. 2, 1926.

Precipitating system. (For precipitating metals from liquids.) A. G. McGregor, London, England. No. 1,753,015. May 4, 1928.

Pen-point alloy (Os-Pt-W-Ni). J. E. Woodward, Brooklyn, N. Y., assignor to Messrs. Kastenhubner & Lehrfeld, New York, N. Y., a Partnership. No. 1,753,161. Dec. 19, 1927.

Alloy (Os-W-Ni). J. E. Woodward, Brooklyn, N. Y., assignor to Messrs. Kastenhubner & Lehrfeld, New York, N. Y., a Partnership. No. 1,753,162. May 22, 1929. (Division of application filed Dec. 19, 1927.)

Track for use in furnaces. L. J. Stanbery and N. T. Branche, Toledo, Ohio, assignors to The Surface Combustion Company, Inc., Toledo, Ohio. No. 1,753,220. Feb. 4, 1929.

Welding-roll screw down. J. J. Kennedy, Pomeroy, Pa., assignor to Bethlehem Steel Company. No. 1,753,241. Dec. 11, 1926.

Method of forming and knurling metal bodies. O. U. Zerk, Cleveland, Ohio, assignor, by mesne assignments, to Alemite Corporation, Chicago, Ill. No. 1,753,258. Apr. 16, 1923.

Annealing box. A. M. Capper, Pittsburgh, Pa., assignor to Duquesne Steel Foundry Company, Pittsburgh, Pa. No. 1,753,261. Mar. 9, 1928.

Welding apparatus and method of welding. J. C. Cromwell, Columbus, Ohio, assignor to The Steel Sanitary Company, Alliance, Ohio. No. 1,753,263. Mar. 18, 1927.

Rolling mill. L. Johnson, Ingram, Pa., assignor to United Engineering & Foundry Company, Pittsburgh, Pa. No. 1,753,268. July 21, 1928.

Testing metallic coatings. K. Pitschner, Bridgeport, Conn., assignor to American Chain Company, Inc. No. 1,753,301. Dec. 22, 1926.

Nickel-plating apparatus. A. B. Schupp, Richmond Hill, N. Y., assignor to Motor Meter Gauge & Equipment Corp., Long Island City, N. Y., by mesne assignments. No. 1,753,350. Dec. 18, 1925.

Chilling mold. J. P. Leary, Baltimore, Md., assignor, by direct and mesne assignments, to The Process Casting Company, Baltimore, Md. No. 1,753,380. July 6, 1928.

Bearing body and method of making same. (Sheet metal lining.) W. H. Klocke, Woodhaven, N. Y., assignor to The Cleveland Graphite Bronze Company, Cleveland, Ohio. No. 1,753,434. Sept. 6, 1927.

Method of making lined bearings. W. H. Klocke, Woodhaven, N. Y., assignor to The Cleveland Graphite Bronze Company, Cleveland, Ohio. No. 1,753,435. Jan. 9, 1928.

Brick or block for regenerators. K. Kniepert, Vienna, Austria. No. 1,753,467. Feb. 11, 1928; in Austria Feb. 19, 1927.

Welding apparatus. H. A. Woofter, Kenton, Ohio, assignor to Swift Electric Welder Company, Detroit, Mich. No. 1,753,492. June 1, 1926.

Method of soldering. H. S. George, Massapequa, N. Y., assignor to Electro Metallurgical Company. No. 1,753,509. May 2, 1927.

Method and apparatus for testing rods. (Tensile shock.) W. L. Reid and F. J. Bascombe, Lima, Ohio. No. 1,753,532. Sept. 20, 1921.

Bearing and method of making same. (Porous body with electro-plated surface.) R. L. Seabury, Toledo, Ohio, assignor to Delco-Remy Corp., Anderson, Ind. No. 1,753,581. July 3, 1926.

Molding apparatus. L. D. Kay, Los Angeles, Calif. No. 1,753,608.

Machine for and method of finishing bushings. H. M. Williams and C. L. Lee, assignors to General Motors Research Corporation both of Dayton, Ohio. No. 1,753,632. May 22, 1923.

Soldering machine. O. V. Badgley, Anderson, Ind., assignor to Delco-Remy Corp., Dayton, Ohio. No. 1,753,639. Mar. 3, 1927.

Metal-working process and apparatus. (For securing tubular member in apertured head.) A. C. Andresen, New York, N. Y., assignor to Chicago Pneumatic Tool Company, New York, N. Y. No. 1,753,677. Aug. 7, 1926.

Conveyer for heat-treating furnaces. C. A. Barrett, Buffalo, N. Y. No. 1,753,679. Oct. 26, 1927.

Apparatus for expanding cup-shaped members. J. E. Batie, assignor to Kelsey-Hayes Wheel Corporation, both of Detroit, Mich. No. 1,753,680. May 2, 1927.

Drawing press. J. E. Dobson, assignor to The Cleveland Punch & Shear Works Co., both of Cleveland, Ohio. No. 1,753,695. July 25, 1927.

Drawing press. R. J. Pardee, Cleveland Heights, Ohio, assignor to the Cleveland Punch & Shear Works Company, Cleveland, Ohio. No. 1,753,717. June 8, 1928.

Metal-protected roofing element and method of making the same. T. Robinson, assignor to Anaconda Sales Company, both of New York, N. Y. No. 1,753,721. May 15, 1926.

Self-heating device such as soldering irons. I. Cowles, Detroit, Mich., assignor to Union Bank of Chicago, Chicago, Ill. No. 1,753,741. July 13, 1925.

Metallic alloy. (Sb-Pb-Sn-Zn-Cu.) H. J. Lorang, assignor of one-half to F. J. Kuna, both of St. Louis, Mo. No. 1,753,748. Dec. 24, 1928.

Manufacture and repair of centrifugal molds. F. C. Langenberg, New York, assignor to United States Cast Iron Pipe & Foundry Co., Burlington, N. J. No. 1,753,747. Dec. 29, 1928.

Rolling mill. G. Asbeck, Düsseldorf-Rath, Germany. No. 1,753,767. Mar. 1, 1928; in Germany, Apr. 12, 1927.

Chromium-plated worm shaft. A. Champion, assignor to A. C. Spark Plug Company, both of Flint, Mich. No. 1,753,773. Oct. 1, 1926.

Furnace for reducing metals. G. C. Cox, and H. K. McIntyre, deceased, Raleigh, N. C., by E. M. McIntyre, executrix, Raleigh, N. C., J. G. McIntyre, New York, N. Y., and M. McIntyre, Cranford, N. J., executors. No. 1,753,822. Oct. 5, 1926.

Machine for forming strips for store-front construction. (*Curving or straightening.*) F. Himmel and I. Himmel, assignors to The Himmel Brothers Co., all of New Haven, Conn. No. 1,753,829. May 1, 1929.

Method of farming bearings. (*Sheet metal lining.*) L. J. Sauer, Oak Park and C. H. Joy, Jr., Chicago, Ill. assignors to C. H. Joy, Sr., Chicago. No. 1,753,837. Oct. 22, 1926.

Apparatus for the reduction of impurities contaminating molten metal. L. Jones, Muncie, Ind. No. 1,753,891. July 19, 1928.

Acid-resistant alloy. (*Ni-Si-Cu-Al.*) C. E. Plummer, La Grange, Illinois, assignor to Electro Metallurgical Company. No. 1,753,904. Nov. 3, 1928.

Manufacture of chains. J. Reid, Watertown, A. M. Leahy, Somerville and C. G. Lutts, Salem, Mass; M. S. Reid, executrix of said J. Reid, deceased. No. 1,753,941. Aug. 10, 1926.

Die for the manufacture of chain. J. Reid, deceased, Watertown, by M. S. Reid, administratrix, Watertown, A. M. Leahy, Somerville and C. G. Lutts, Salem, Mass. No. 1,753,942. Sept. 21, 1928.

Method of making ductile iron chromium aluminum alloys. (*Thermal and mechanical treatments.*) V. B. Browne, Brackenridge, Pa. No. 1,754,008. Dec. 19, 1927.

Welded joint. F. Rosenberg, Spandau, Germany, assignor to General Electric Company. No. 1,754,051. Oct. 8, 1928; in Germany Nov. 22, 1927.

Coated metallic-arc weld rod and method of making the same. R. Stresau, Wauwatosa, assignor to A. O. Smith, Corporation, Milwaukee, both in Wisconsin. No. 1,754,063. Mar. 12, 1925.

Electroplating bath. (*For chromium plating.*) J. Bedo, assignor to Permachrome Process Corporation, both of Cleveland, Ohio. No. 1,754,075. July 5, 1928.

Apparatus for extracting pipes and like cylindrical articles from the molds in which they were cast. J. E. Hurst, Thorncliffe, near Sheffield, England, and E. B. Ball, Kilmarnock, Scotland, assignors to Centrifugal Castings, Ltd., Kilmarnock, Scotland. No. 1,754,106. Dec. 3, 1928; in Great Britain Jan. 17, 1928.

Electrode suitable for arc welding. F. Meunier, Hyon les Mons, Belgium, assignor to La Soudure Electrique Autogène, S.A., Brussels, Belgium No. 1,754,116. Mar. 8, 1929; in France Mar. 12, 1928.

Electrolytic recovery of metals. (*Production of nickel.*) S. C. Smith, London, England. No. 1,754,125. Apr. 19, 1929; in Great Britain Mar. 30, 1928.

Method of recovering gasifiable metals as oxides. F. Johannsen, Magdeburg, Germany, assignor to Fried. Krupp Grusonwerk, Akt.-Ges., Magdeburg-Buckau, Germany. No. 1,754,169. Jan. 4, 1926; in Germany May 26, 1925.

Process for treating ores and metallurgical products, slags, and the like. F. Johannsen, Magdeburg, Germany, assignor to the Firm Fried. Krupp Grusonwerk Akt.-Ges., Magdeburg-Buckau, Germany. No. 1,754,170. Oct. 14, 1926; in Germany Nov. 5, 1925.

Wire-tempering apparatus. A. W. Harris, F. M. Suchke and J. L. King, Atlanta, Georgia, assignors to Atlanta Harness & Reed Mfg. Company. No. 1,547,190. Apr. 23, 1928.

Covered weld rod for electric-arc welding. R. Stresau, Wauwatosa, assignor to A. O. Smith Corp., Milwaukee, both of Wisconsin. No. 1,754,206 Mar. 12, 1925 original, this one Apr. 18, 1929.

Spiral feed conveyer for heat-treating furnaces. M. Winter, Wrentham, Mass., assignor to the Surface Combustion Co., Inc., Toledo, Ohio. No. 1,754,294. Sept. 25, 1928.

Insert-holding device for casting molds. J. S. Thompson, New York, N. Y., assignor to The American Brake Shoe and Foundry Co., Wilmington, Del. No. 1,754,340. June 28, 1928.

Electric-welding tool. J. Endebak, Chicago, Ill. No. 1,754,353. Nov. 26, 1927.

Bearing metal. (*Pb-Sn-Sb-As-Cd.*) P. Kemp, Vienna, Austria. No. 1,754,364. Jan. 11, 1928; in Poland Jan. 17, 1927.

Annealing pot. R. S. Stewart, Chicago, Ill., assignor to The American Brake Shoe & Foundry Co., New York, N. Y. No. 1, 254,3721-4. Oct. 12, 1927.

Soldering tool. S. Baracate, Troy, N. Y. No. 1,754,382. July 5, 1929.

Annealing pot. M. W. Gleisner, Racine, Wis., assignor to The American Brake Shoe & Foundry Co., New York, N. Y. No. 1,754,423. Oct. 14, 1927.

Method of removing carbon impurities from tantalum. C. W. Balke, Highland Park, Ill., assignor to Fansteel Products Company, Inc., North Chicago, Ill. No. 1,754,453. Sept. 2, 1926, renewed Feb. 28, 1929.

Filling mold. A. Kadow. Toledo, Ohio, assignor of one-half to Wilber Owen and Charles W. Owen, Toledo, O. No. 1,754,469. June 19, 1926.

Process for protecting easily-oxidizable metals such as those having a base of magnesium, aluminum, calcium, etc. G. Michel, Bagneux, France. No. 1,754,481. Mar. 8, 1928; in France Mar. 12, 1927.

Welding. W. B. Miller, Flushing, N. Y., assignor to Oxweld Acetylene Co. No. 1,754,566. Jan. 27, 1926.

Method of and apparatus for straightening annealing boxes. A. W. Earl, Cleveland, O., assignor to The American Steel and Wire Co., of New Jersey. No. 1,754,616. July 21, 1927.

Method of welding. W. R. Linden, Palisades Park, N. J., assignor to The Linde Air Products Co. No. 1,754,721. Mar. 9, 1926.

Rolling strip metal. C. H. Elliott, Youngstown, O., assignor to Republic Iron and Steel Co., Youngstown, O. No. 1,754,745. June 13, 1929.

Purifying light-metal alloys. J. A. Gann, assignor to The Dow Chemical Co., both of Midland, Mich. No. 1,754,788. July 13, 1923.

Slag-reducing process. T. F. Baily, Alliance and L. G. Pritz, Canton, O; said Pritz assignor to said Baily. No. 1,754,845. Jan. 28, 1928.

Mechanism for opening sheets. R. Edwards, Martins Ferry, O. No. 1,754,852. Oct. 24, 1923.

Electric welding machine. C. T. Hatch, assignor to Union Steel Products Co., both of Albion, Mich. No. 1,754,948. Sept. 21, 1928.

Welding table. H. Schmuckler, Berlin, Germany. No. 1,755,031. Nov. 10, 1928; in Germany May 5, 1927.

Method of making molds. (*Welding process.*) J. R. Tition, Kenmore, O., assignor to The Miller Rubber Co., Akron, O. No. 1,755,038. May 12, 1928.

Electric furnace. R. M. Cherry, Schenectady, N. Y., assignor to General Electric Co. No. 1,755,051. Mar. 1, 1928.

Furnace. (*Heat treating.*) A. N. Otis, Schenectady, N. Y., assignor to General Electric Co. No. 1,755,072. Aug. 8, 1927.

Austrian Patents

(Patents whose term began December 15, 1929).

Subject of Invention, Patentee and Patent No.

Mold. Bohn Aluminum and Brass Corporation, Detroit, Mich. No. 117,515.

Process for making steel castings. Gesellschaft für Förderanlagen Ernst Heckel m. b. H., Saabrücken, Germany. No. 117,514.

Process for making hollow castings in permanent molds. B. Fassl, Vienna, Austria. No. 117,528.

Process for making and collecting zinc oxide free from sulphur-oxygen compounds and the like. The New Jersey Zinc Company, New York, N. Y. No, 117,438.

Process for reducing zinciferous materials and for obtaining zinc products, The New Jersey Zinc Company, New York, N. Y. No. 117,445.

Process and apparatus for reducing zinciferous materials. The New Jersey Zinc Company. New York, N. Y. No. 117,446.

Externally-heated vertical retort for reducing zinciferous material. The New Jersey Zinc Company, New York, N. Y. No. 117,447.

Process for degasifying light metals, especially aluminum and aluminum alloys. Vereinigte Aluminium-Werke Akt.-Ges., Lautawerk, Lausitz, Germany. No. 117,465.

Process for obtaining metallic mercury from prepared material containing mercury, by distillation and condensation. Dwight and Lloyd Metallurgical Co., New York, N. Y. No. 117,667.

Process for producing malleable chromium-molybdenum-nickel alloys. T. D. Kelly, London, England. No. 117,448.

Process for making aluminum alloys. A Geyer, Paris, France. No. 117,451.

Process and cathode for the electrolytic production of magnesium and alkaline earth metals. A. C. Jessup, Paris, France. No. 117,437.

Process for the electrolytic production of pure aluminum from crude aluminum and aluminym alloys and the like. Aluminium-Industrie Akt.-Ges., Neuhausen, Switzerland. No. 117,439.

Electrolytic process for working up difficultly decomposable alloys. T. Kittl, Vienna, Austria. No. 117,443.

Electrolytic process for obtaining aluminum in dense form from crude aluminum, alloys and the like. Aluminium-Industrie Akt.-Ges., Neuhausen, Switzerland. No. 117,449.

Method of regulating electric arc furnaces. A.E.G.-Union Elektricitäts Gesellschaft, Vienna, Austria, assignee of S. Schey, Berlin, Germany. No. 117,453.

Apparatus for the electrolytic production of sheet or tubing. E. Kelsen, Vienna, Austria. No. 117,444.

Process for rendering wax-like or soap-like substances electrically conducting, particularly for the production of matrices for phonograph records. The Gramophone Co., Ltd., Hayes, England. No. 117,452.

Process for producing metal coatings on rubber articles, especially dental plates and the like. M. Ow-Eschingen, Vienna, Austria. No. 117,455.

Process for making sheet tubing. Metallwerk Armin Flax, Teplitz-Schönau, Germany. No. 117,429.

Extrusion press. Fried. Krupp Grusonwerk Akt.-Ges., Magdeburg-Buckau, Germany. No. 117,433.

Mandrel holder for vertical lead cable presses. Fried. Krupp Grusonwerk Akt.-Ges., Magdeburg-Buckau, Germany. No. 117,436.

Cutting or welding machine. A. Schmidt, Wien-Strebersdorf, Austria. No. 117,410.

Process and machine for pressing or rolling hollow sections with the aid of a sand filling. Fried. Krupp Akt.-Ges., Essen, Ruhr, Germany. No. 117,432.

Furnace for sintering, calcining or roasting materials and method of operating the same. E. K. Loesche, Berlin-Lankwitz, Germany. No. 117,589.

British Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Electric furnaces. A. Sadler (G. B. Shipley and H. Alinder). No. 326,517. Sept. 15, 1928.

Manufacture of articles from alloys. J. Y. Johnson (I. G. Farbenindustrie Akt.-Ges.). No. 326,518. Sept. 15, 1928.

Forming of sheet metal. E. G. Budd Manufacturing Co. No. 302,723. Dec. 21, 1927.

Manufacture and production of compact metal articles from metal powders. J. Y. Johnson (I. G. Farbenindustrie Akt.-Ges.). No. 326,536. Dec. 13, 1928. (Addition to 19901/28.)

Reinforcing-structures for blast-furnace casings. P. Stern and Mannesmann-Rohren-Werke. No. 326,513. Dec. 14, 1928.

Annealing-furnaces. J. R. Garner and J. H. Royston. No. 326,562. Dec. 20, 1928.

Apparatus for cleaning metal articles. J. J. V. Armstrong (Hahn H. and H. Sauter, (trading as Hahn & Kolb). No. 326, 588. Jan. 1, 1929.

Apparatus for transforming pig-iron into desulphurized and dephosphorized steel, or into pure iron. Carbonisation Soc. Generale D'Exploitation des Carbones. No. 303,891. Jan. 12, 1928.

Castings of large dimensions, especially frames for railway rolling-stock. N. Leonard. No. 316,997. Aug. 8, 1928.

Apparatus for charging kilns or furnaces. P. J. Beswick. No. 326,613. Jan. 24, 1929.

Welding method and composition. P. L. & M. Co. No. 317,361. Aug. 14, 1928.

Producing metals from their oxide ores. Trent Process Corporation. No. 306,949. Feb. 28, 1928.

Electric annealing or like furnaces. P. Mene. No. 306,969. Feb 29, 1928.

Molds for type line-casting machines. Intertype Corporation. No. 312,223. May 22, 1928.

Production of dark oxidic coatings on magnesium and magnesium alloys. W. W. Trigg (Sprenger Corporation). No. 326,693. April 23, 1929.

Method of and apparatus for rolling metals. P. Robinson. No. 326,696. April 25, 1929.

Methods of working normally brittle sheet metal. British Thomson-Houston Co., Ltd. No. 311,290. May 8, 1928.

Means for feeding the wire in electric arc welding-machines. International General Electric Co., Inc. No. 312,237. May 22, 1928.

Methods of and apparatus for making seamless tubes. Babcock & Wilcox Tube Co. No. 314,523. June 30, 1928.

Molds for casting metals. A. E. White (Aluminium, Ltd.). No. 325,554. Aug. 21, 1928

Manufacture and production of metallic powders suitable for the cores of magnets. J. Y. Johnson (I. G. Farbenindustrie Akt.-Ges.). No. 325,526. Sept. 21, 1928.

Provision of insulating-coatings on aluminium or aluminium alloys. Associated Electrical Industries, Ltd. No. 300,912. Nov. 19, 1927.

Method of applying zinc coatings to iron articles. T. Liban. No. 325,540. Nov. 21, 1928.

Electric furnaces. Wild-Barfield Electric Furnaces, Ltd. No. 325,548. Nov. 21, 1928; and L. W. Wild.

Gap-rolls for use in rolling metal. D. Smith. No. 325,596. Nov. 24, 1928.

Methods of performing brazing, soldering and similar operations. Unique & Unity Cycle Co., Ltd., and J. Munn. No. 325,647. Jan. 1, 1929.

Castings of large dimensions and particularly frames for railway rolling-stock. N. Leonard. No. 325,649. Jan. 2, 1929.

Electric heating-elements. Naamlooze Vennootschap Technisch Handels-Bureau Thabur. No. 303,420. Jan. 2, 1928.

Preparation of refractory linings of crucibles for coreless electrical induction furnaces. N. R. Davis, and Associated Electrical Industries, Ltd. No. 325,661. Jan. 8, 1929.

Bending of metal strip or sheet. H. Renold, Ltd., and A. Renshaw. No. 325,683. Feb. 9, 1929.

Method of welding silicon-containing steel alloys. F. Krupp Akt.-Ges. No. 313,434. June 11, 1928.

Production of beryllium alloys, in particular those with a high beryllium content by means of fused electrolysis. Siemens & Halske Akt.-Ges. No. 325,762. Nov. 13, 1928.

Ignition furnaces. Metallges. Akt.-Ges. No. 318,197. Aug. 30, 1928.

Methods for end-grating and molding malleable cast iron boot protectors and the like. W. T. Giles. No. 325,779. Aug. 13, 1929.

Welded structures. E. F. Ehrhardt (T. E. Murray). No. 325,551. Aug. 21, 1928.

Electrodes for the electric heat-treatment of metallic articles. F. W Thompson. No. 325,552. Oct. 18, 1928.

Heat-treatment of stee land iron-Ges. für Industriegasverwertung. No. 297,-796. Sept. 28, 1927.

Process and device for measuring high temperatures, specially of incandescent bodies. A. Dornfried, E. Karcher and A. Single. No. 325,863. Sept. 28, 1928.

Checkerwork regenerators, and bricks for use in the construction thereof. B. Marks. (Open Hearth Combustion Co.) No. 325,789. Oct. 20, 1928.

Hollow spun articles. J. Gloster, Ltd., and L. J. Gloster. No. 325,841. Nov. 30, 1928.

Heating or melting of metals or alloys by induced currents of electricity. C. Tama, and Electric Furnace Co., Ltd. No. 325,940. Jan. 7, 1929.

Machines for casting metal pipes. Soc. Anon. des Hauts-Fourneaux et Fonderies de Pont-à-Mousson. No. 310,511. Apr. 27, 1928.

Adjustable supporting-mechanism for straightening rolls of plate-straightening machines. F. Ungerer. No. 326,033. Mar. 21, 1929.

Rolling of iron. C. Rötzel. No. 309,176. April 7, 1928.

Rolling-device for the manufacture of iron and steel balls. O. Hering. No. 310,520. Apr. 8, 1929.

Manufacture of printing-plates. H. Buschmann. No. 315,855. July 21, 1928.

Ingot molds. G. W. Naylor, J. F. Naylor, W. Naylor and C. E. Naylor. No. 326,785. Sept. 19, 1928.

Metal-coated materials. L. W. Cutler, C. A. Klein and Associated Lead Manufacturers, Ltd. No. 326,792. Dec. 14, 1928.

Process for improving lead. O. Y. Imray (I. G. Farbenindustrie Akt.-Ges.) No. 326,818. Dec. 18, 1928.

Manufacture of aluminium-silicon alloys. Soc. D'Electrochimie, D'Electrométallurgie et des Aciéries Electriques D'Ugine. No. 302,692. Dec. 20, 1927.

Method of casting magnesium or magnesium alloys. I. G. Farbenindustrie Akt.-Ges. and A. L. Mond. No. 326,820. Dec. 19, 1928.

Manufacture of vanadium-aluminium-silicon alloys. Vanadium Corporation of America. No. 305,202. Feb. 2, 1928.

Horizontal presses for extruding metal. F. Krupp Grusonwerk Akt.-Ges. No. 308,569. March 24, 1928.

Cores for use in casting metals. H. A. Cope (A. C. Waters). No. 326,927. Jan. 23, 1929.

Welding metals and alloys. I. G. Farbenindustrie Akt.-Ges. No. 305,999. Feb. 13, 1928.

Pressing-tools for the spinning of metals and alloys. P. C. Christiansen. No. 307,034. March 1, 1928.

Aluminum alloys. O. Reuleaux. No. 309,586. April 13, 1928.

Treating ores, metallurgical products or the like. Metallges. Akt.-Ges. No. 317,001. Aug. 8, 1928.

Apparatus for introducing material to be rolled into rolling-mills. Vereinigte Stahlwerke Akt.-Ges., and L. Klein. No. 327,084. Oct. 19, 1928.

Wire-drawing machines. Nacken. No. 315,080. (Amended specification.)

Electric induction smelting-furnaces. J. Harden. No. 302,308. Dec. 14, 1927.

Manufacture of carbonized metallic wire or ribbon. Westinghouse Electric & Manufacturing Co. No. 305,467. Feb. 4, 1928.

Devices for automatically winding coils of wire in layers. A. Zopp. No. 305,045. Jan. 28, 1928.

Process for cementing and hardening iron, iron alloys, and steel. Deutsche Gold- under Silber-Scheideanstalt Vorm. Roessler. No. 310,837. May 1, 1928. (Addition to 304,209 and 308,963.)

Producing a protecting layer on chrome baths for preventing formations of chrome mists. R. Blasberg. No. 327,293. April 8, 1929.

Means for measuring the permeability of sands and other aggregates. British Cast Iron Research Association, W. J. Rees and J. G. A. Skerl. No. 327,306. April 19, 1929.

Rosin-Core solder. P. C. Ripley. No. 327,337. June 7, 1929.

Rolling-mills. Vereinigte Stahlwerke Akt.-Ges. No. 316,215. July 25, 1928.

Machines for making rivets, bolts and the like. R. N. A. Pillans. No. 327,354. June 29, 1929.

Electric furnaces of the inductor type. E. F. Northrup. No. 316,662. Aug. 2, 1928.

Electrical resistance welding with rolling electrodes. E. A. Rosengrens, Kassakaps-Fabriks Aktiebolag. No. 327,361. Mar. 12, 1929.

Process of improving lead. O. Y. Imray (I. G. Farbenindustrie Akt.-Ges.). No. 327,106. Dec. 18, 1928.

Galvanizing baths. J. Summers & Sons, Ltd., and H. B. Freeman. No. 327,181. Aug. 3, 1929.

Manufacture of metal dust. Standard Telephones & Cables, Ltd., J. C. Chaston and A. F. B. Norwood. No. 327,419. Oct. 4, 1928.

Wire and like devices, and their manufacture. W. H. Ames and Whitecross Co., Ltd. No. 327,384. Dec. 1, 1928.

Zinc base alloys, and articles made therefrom. New Jersey Zinc Co. No. 305,651. Feb. 9, 1928.

Bell hoisting mechanism for blast furnaces. Waygood-Otis, Ltd. No. 304,772. Jan. 26, 1928.

Cadmium plating. C. H. Humphries. No. 304,668. Jan. 23, 1928.

Melting and deoxidizing metals and alloys. W. Reitmeister. No. 327,570 April 5, 1929.

Manufacture of metal tires. Eisen-und Stahlwerk Hoesch Akt.-Ges. No. 310,325. April 23, 1928.

Method for magnetically detecting cracks in steel parts by magnetism. W. L. Lorkin, E. E. Daglish and H. B. Swift. No. 327,603. May 1, 1929.

Blackening by oxidation of iron and steel, and articles thereof. L. Taricco. No. 327,615. May 14, 1929.

Electrolyzer for separation of tin from tin salt solutions. L. Ughetti-La Corsa. No. 313,166. June 9, 1928.

Method and device for flanging plate discs. O. Wild and L. Wild. No. 313,-967. June 20, 1928.

Improving the fatigue strength of metal workpieces. A. L. Mond (I. G. Farbenindustrie Akt.-Ges.). No. 327,660. Aug. 15, 1929.

Roller spun metal manufacture. W. R. Harrison. No. 327,667. Sept. 30, 1929.

Canadian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Mechanical kiln. Balz-Erzröstung Ges.m.b.H., Gleiwitz, Germany, assignee of G. Balz, Tübingen, Germany. No. 298,815. May 16, 1929

Wire take-off mechanism. Love Brothers, Inc., assignee of A. K. Sanderson, both of Aurora, Ill. No. 298,907. May 1, 1929.

Wire polishing machine. Love Brothers, Inc., assignee of A. K. Sanderson, both of Aurora, Ill. No. 298,908. May 3, 1929.

Open hearth furnaces. "Terni" Societa per l'Industria e l'Elettrica, assignee of F. Fiorelli, both of Terni, Italy. No. 298,951. July 25, 1929.

Welding apparatus. The Trussbilt Steel Doors, Inc., assignee of the Gross Metal Products Co., assignee of A. R. Gross, all of St. Paul, Minn. No. 298,952. May 9, 1929.

Metallic filament for incandescent lamps. R. Stewart, London, England assignee of W. Berger, Dresden, Germany. No. 298,963. Aug. 19, 1927.

Manufacture of magnesium and its alloys. H. O. Berg, Paris, assignee of G. Michel, Bagneux, Seine, France. No. 298,968. Sept. 17, 1925.

Apparatus for handling metal. (Binding sheet metal into packs.) R. T. Romine, Mt. Clemens, Mich. No. 298,971. Oct. 7, 1927.

Process of treating iron pyrites. S. I. Levy, London, England. No. 299,-036–7. Mar. 1, 1928.

Mechanical kiln. Balz Erzröstung Ges.m.b.H., assignee of Erzröstung G.m.b.H., both of Gleiwitz, Germany, assignee of G. Balz, Tübingen, Germany. No. 299,014. Apr. 23, 1928.

Welding machine. The Metropolitan Engineering Co., assignee of L. H. Hoffer, both of Brooklyn, N. Y. No. 299,144. May 25, 1929.

Welding apparatus. The Metropolitan Engineering Co., Brooklyn, N. Y., assignee of G. H. Phelps, Warehouse Point, Conn. No. 299,145. Aug. 5, 1929.

Electrode holder (for welding). A. E. Bicsey, McKeesport, Pa. No. 299, 222. Nov. 5, 1929.

Rolling mill. S. F. Williams, Montreal, Que. No. 299,287. Sept. 6, 1927.

Method of manufacturing magnesite bricks. The American Smelting and Refining Co., New York, N. Y., assignee of B. M. O'Hara, Westfield, N. J. and E. A. Slagle, Trenton, N. J. No. 299,290. Mar. 25, 1929.

Electric welding method. The Trucson Steel Co., assignee of G. A. Hughes, both of Youngstown, Ohio. No. 299,401–2. Oct. 4, 1929.

Process for treating electrolytically the cylinders of rotary printing presses. L. Seemant, Paris, and H. Kuppel, Clichy, Seine, assignee of L. Semeant, Paris, France. No. 299,429. May 19, 1927.

Welding apparatus. J. C. White, Eureka, Calif. No. 299,435. Aug. 24, 1929.

Sectional buckstay. J. P. McLimans, Duluth, Minn. No. 299,440. Apr. 2, 1929.

Slag pocket. J. P. McLimans, Duluth, Minn. No. 299,441. Apr. 2, 1929.

Apparatus for dipping of tubes or rods for pickling, cleaning, etc. H. Trevorrow, Birmingham, England. No. 299,513. Apr. 29, 1929.

Process of manufacturing non-sagging helical bodies of highly refractory metals. The Canadian General Electric Co., Toronto, Ont., assignee of N. V. Philips' Gloeilampenfabriken, assignee of J. A. van Liempt and H. W. Geiss, all of Eindhoven, Netherlands. No. 299,533. Mar. 27, 1925.

Method of making coated iron or steel articles. The Parker Rust-Proof Co., assignee of R. R. Tanner, both of Detroit, Mich. No. 299,596. Aug. 21, 1929.

Method of making nut blanks. The Russell, Burdsall and Ward Bolt and Nut Co., Port Chester, N. Y., assignee of S. W. Avis, Greenwich, Conn. No. 299,599. June 13, 1929.

Roller type conveyor for heat treatment furnaces. F. A. Fahrenwald, Chicago, Ill. No. 298,305. Mar. 11, 1929.

Electric furnace. E. M. Bornand and H. A. Schlaepfer, Geneva, Switzerland. No. 298,311. Oct. 25, 1929.

Aluminum alloys. P. Bethelemy and H. de Montby, Paris, France. No. 298,315. Jan. 16, 1928.

Roasting and reduction of metallic ores. F. L. Duffield, London, England No. 298,342. Mar. 30, 1928.

Reduction of ores F. L. Duffield, London, England. No 298,343. Aug. 29, 1928.

Molding apparatus (for casting duplex ingots). Aluminium Limited, Toronto, Ont., assignee of S. H. Carbis, Tarentum, Pa. No. 298,392 Nov. 5, 1928.

Manufacture of metal foils. The American Machine & Foundry Co., New York, N. Y., assignee of W. J. Hawkins, Montclair, N. J. No 298,395. Dec. 29, 1928.

Process and apparatus for treating strip metal. The Copperized Steel Limited, Newport, Monmouthshire, England, assignee of the Copper Plate Sheet & Tube Co., assignee of W. E. Watkins, both of New York, N. Y. No. 298,420. Aug. 26, 1927.

Metallic sheet and film for offset printing (Mg-Al alloys). I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany, assignee of H. Dibelka, Düsseldorf, Germany. No. 298,424. Jan. 23, 1928.

Process for improving the resistance to corrosion of magnesium alloys. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany, assignee of A. Beck and Seibel, both of Bitterfeld, Germany. No. 298,425. Feb. 2, 1929.

Process of improving the fatigue strength of metallic implements. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., assignee of G. Schreiber, Bitterfeld, Germany. No. 298,429. Sept. 18, 1929.

Rail Steel. The Granular Iron Co., New York, N. Y., assignee of J. K. Smith, Detroit, Mich. No. 298,433. Apr. 5, 1927.

Steel (free from ferrite-dissolved nitrides). The Granular Iron Co., New York, N. Y., assignee of J. K. Smith, Detroit, Mich. No. 298,434. Apr. 19, 1927.

Process of making steel. The Granular Iron Co., New York, N. Y., assignee of J. K. Smith, Detroit, Mich. No. 298,435. Apr. 19, 1927.

Production of expanded load-bearing members. The Kalman Steel Co., Inc., assignee of M. D. Brody, both of Chicago, Ill. No. 298,467. May 17, 1928.

Apparatus for expanding cup-shaped members. The Kelsey-Hayes Wheel Corp., assignee of J. E. Batie, both of Detroit, Mich. No. 298,468. July 3, 1928.

Liquid core binder. The Lindsay McMillan Co., assignee of W. R. Pate and J. A. Gitzen, all of Milwaukee, Wis. No. 298,469. Oct. 19, 1929.

Method and apparatus for hardening articles. The Reo Motor Car Co., assignee of W. G. Heldorf, both of Lansing, Mich. No. 298,485. Feb. 6, 1928.

Process of separating cobalt and other metals from cobalt ores. The Rideau Smelting & Refining Co., Ltd., Smith's Falls, Ont., assignee of P. E. Macklin, Newark, N. J. No. 218,531. Dec. 15, 1928.

Device for operating shaft furnaces. O. Hubmann, Frankfurt a.M., and F. Voerkel, Hoechst a.M., Germany. No. 298,541. July 25, 1928.

Apparatus for extracting volatile metals from their ores. H. E. Coley, London, England. No. 298,555. Jan. 22, 1929.

Rolling mill. P. Eisner, Berlin, Germany. No. 298,558. Mar. 8, 1929.

French Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Method of obtaining air for the blast of blast furnaces or similar installations. G. Malyoth. No. 683,372. Oct. 16, 1929.

Fine adjustment for the upper roll of a pilger rolling mill. E. Rober. No. 683,453. Oct. 17, 1929.

Thermal or electrothermal process for the reduction of oxides to obtain volatile metals such as zinc. O. Dony. No. 683,455. Oct. 17, 1929.

Improvements to the process for treating zinc ores and mixed ores by volatilization. A. Folliet and N. Sainderichin. No. 683,532. Oct. 19, 1929.

Device applicable to rolling mills for rolling material into bars. Aktiebolaget Svenska Kullagerfabriken. No. 683,706. Oct. 22, 1929.

Forging machine. Schiess-Defries Akt.-Ges. No. 683,452. Oct. 17, 1929.

Improvements in the pickling of metals. The Barrett Co. No. 683,470. Oct. 17, 1929.

Process for utilizing difficultly utilizable alloys containing copper. W. Kroll and Hüttenwerke Trotha Akt.-Ges. No. 683,540. Oct. 10, 1929.

Induction furnace for melting, annealing, hardening, etc., in which the lines of force are perpendicular to the axis of the cylindrical working chamber C. Lorenz Akt.-Ges. No. 683,393. Oct. 16, 1929.

Induction furnace. H. Zepernick. No. 683,685. Oct. 21, 1929.

Refractory product. T. R. Haglund. No. 683,465. Oct. 17, 1929.

Roasting and calcining furnace. V. Zieren. No. 683,868. Oct. 24, 1929.

Process for roasting copper pyrites allowing a reduction in the quantity of sulfurous gases liberated. M. Miyake. No. 683,892. Oct. 24, 1929.

Process for recovering the tin contained in tin plate or other materials containing tin. The African Tin Recovery Co., Ltd. No. 683,900. Oct. 25, 1929.

Improvements in the fabrication of billets, bars, and similar metallic objects. F. O. W. Harbord and V. Harbord. No. 683,946. Oct. 25, 1929.

Process for the preparation of materials containing aluminum sulphide and oxide. International Patent Corporation. No. 683,970. Oct. 26, 1929.

Process and apparatus for freeing cast iron of gases. A. Le Thomas. No. 683,996. Oct. 28, 1929.

Process for obtaining tungsten or tungsten-thorium alloys which are free from oxygen. A. Paez. No. 684,158. Oct. 29, 1929.

Improvements to processes for fabricating metallic tubing or shells by pressing. Felten & Guilleaume Carlswerk Akt.-Ges. No. 683,785. Oct. 23, 1929.

Paste for soldering all metals at low temperatures. J. A. Rognon. No. 683,813. Jan. 30, 1929.

mprovements to processes for fabricating annular objects, especially for the frames of electrical machinery and for cylindrical tanks for fluids under pressure. Compagnie Française pour l'Exploitation des Procédés Thomson-Houston. No. 684,056. Oct. 29, 1929.

Cold-junction correction device for indicating pyrometers using a thermocouple. Établissements M. Chenaille. No. 683,878. Oct. 24, 1929.

Improvements to electric furnaces and to their heating resistances. Compagni Française pour l'Exploitation des Procédés Thomson-Houston. No. 683,769. Oct. 23, 1929.

Improvements to electric furnaces and to their heating systems. Compagnie Française pour l'Exploitation des Procédés Thomson-Houston. No. 683,770. Oct. 23, 1929.

Device for increasing air pressure, particularly for increasing the pressure of the combustion air for blast furnaces, hot blast stoves and other installations. Askania Werke Akt.-Ges., vormals Centralwerkstatt Dessau und Carl. Bamberg Friedenau. No. 683,962. Oct. 26, 1929.

Process for the continuous sintering of ores, fine concentrates or ferrous materials. A. Folliet and N. Sainderichin. No. 684,174. Oct. 30, 1929.

Penetrating metallic autocementation process for ferrous products. A. Folliet and N. Sainderichin. No. 684,175. Oct. 30, 1929.

Process for producing homogeneous titanium or ferro-titanium melts capable of being poured. W. Mathesius and H. Mathesius. No. 684,210. Oct. 30, 1929.

Process and device for making bricks for the tuyères of converter bottoms. Maschinenfabrik Meer Akt.-Ges. No. 684,299. Nov. 2, 1929.

Arch for metallurgical furnaces. W. Alberts. No. 684,457. Nov. 6, 1929.

Process for obtaining iron-titanium alloys containing a high percentage of titanium. W. Mathesius and H. Mathesius. No. 684,474. Nov. 6, 1929.

Zinc base alloy for chill casting. The New Jersey Zinc Co. No. 684,568. Nov. 7, 1929.

Device for charging furnaces for producing aluminum. Vereinigte Aluminium Werke Akt.-Ges. No. 684,640. Nov. 8, 1929.

Refined lead which is resistant to the action of sulphuric acid. I. G. Farbenindustrie Akt.-Ges. No. 684,669. Nov. 9, 1929.

Improvements to processes for making tubing. H. W. Bundy. No. 684,408. Nov. 5, 1929.

Improvements to electric butt-welding or upsetting machines. J. E. J. Languepin. No. 684,518. Feb. 11, 1929.

Process for making rivets. Vereinigte Leichtmetall Werke G.m.b.H. and C. Schwichtenberg. No. 684,548. Nov. 7, 1929.

Device for casting metals. E. Bornand and H. A. Schlaepfer. Addition Patent No. 36,558. (First addition to Patent No. 666,271.) Feb. 19, 1929.

Electric furnace. Société Anonyme Statherme. No. 684,345. Nov. 4, 1929.

Improved galvanoplastic apparatus. No. 684,383. Nov. 5, 1929. W. J. Pitt. No. 684,383. Nov. 5, 1929.

Induction muffle furnace with autoregulation of temperature. V. Sorrel and L. A. Lafont. No. 684,589. Nov, 8, 1929.

Process for the uniform electric heating of granular substances. I. G. Farbenindustrie Akt.-Ges. Addition Patent No. 36,561. (First addition to Patent No. 617,004.) Feb. 23, 1929.

Improvements in the operation of rolling sheet metal. The American Rolling Mill Co. No 682,642. Oct. 2, 1929.

Process for treating ferromagnetic alloys to obtain special magnetic properties. Vereinigte Stahlwerke Akt.-Ges. No. 682,656. Oct. 2, 1929.

Device for conveying material to be rolled during rolling. F. Chamier. No. 682,730. Oct. 3, 1929.

Liquid-fuel blowpipe. Liquid Fuel Cutting and Welding Corporation. No. 682,650. Oct. 2, 1929.

Device for compressing the mold material in the production of foundry molds and cores. M. Grindal. No. 682,726. Oct. 3, 1929.

Means for reducing the idling period of tubing mills by mechanical feeding of the hollow billets and by mechanical interchanging of the mandrels. J. Sommer. No. 682,894. Oct. 8, 1929.

Galvanizing process. Société Anonyme Waldberg. No. 682,908. Oct. 8, 1929.

Suspension device for electrodes. P. Bourgeois. No. 682,574. Oct. 1, 1929.

Battery of cells for electrolytic treatments. P. Bourgeois. No. 682,575. Oct. 1, 1929.

Improvements to electric induction furnaces. Associated Electrical Industries, Ltd. No. 682,873. Oct. 7, 1929.

Chromium-plating of brass. Metals Protection Corporation. No. 682,915. Oct. 8, 1929.

Galvanic and electrolytic apparatus. G. L. A. Chaillon. Addition. Patent No. 36,459. (First addition to No. 659,226.) Dec. 7, 1928.

Process and apparatus for recovering oil from metal chips. The Timken Roller Bearing Co. No. 682,723. Oct. 3, 1929.

Process for separating waste metal in deep drawing operations. Hirsch Kupfer und Messingwerke. No. 683,068. Oct. 10, 1929.

Process for increasing the elongation, as well as the pliability and rollability of aluminum alloy sheet, strip, wire, etc. Société Anonyme pour l'Industrie de l'Aluminium. No. 682,978. Oct. 9, 1929.

Device for casting aluminum and its alloys. Vereinigte Aluminium Werke Akt.-Ges. No. 683,052. Oct. 10, 1929.

Process and apparatus for the production of sponge iron from iron ore. Fried. Krupp Akt.-Ges., Friedrich Alfred Hütte. No. 683,064. Oct. 10, 1929.

Alloy and method of welding it to iron, aluminum, itself and to any other metal. L. J. Bercin. No. 682,100. Oct. 9, 1929.

Improvements in the preparation of metals. P. Mouravieff. No. 683,159. Jan. 8, 1929

Improvements in the manufacture of iron and steel in the basic converter. J. B. Richarme. No. 683,192. Jan. 25, 1929.

Apparatus for roasting ores having a high sulfur content. Metallgesellschaft Akt.-Ges. No. 683,260. Oct. 14, 1929.

Improved aluminum alloy. Rolls-Royce, Ltd. No. 683,272. Oct. 14, 1929.

Melting apparatus, comprising a reverberatory furnace and a cupola. Maschinenfabrik Esslingen. No. 683,286. Oct. 14, 1929.

Improvements to molding machines. E. O. Beardsley and W. F. Piper. No. 683,073. Oct. 10, 1929.

Process and machines for making tubing. Société Anonyme des Hauts-Fourneaux & Fonderies de Pont-à-Mousson. No. 683,142. Oct. 11, 1929.

Process for drawing tubing. Marcel Bassot & Co. No. 683,177. Jan. 24, 1929.

German Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Rolling mill, particularly for the production of objects out of difficultly deformable metals and alloys. Heraeus-Vacuum-Schmelze Akt.-Ges., and W. Rohn, Hanau a.M., Germany. No. 496,057. Sept. 9, 1926.

Gas collector for blast furnaces and other shaft furnaces, with a device for retaining the dust and with one or more laterally placed pipes for leading off the gases. Vereinigte Stahlwerke Akt.-Ges., Düsseldorf, Germany. No. 496,067. Sept. 12, 1928.

Coil for high-frequency induction furnaces. Hirsch, Kupfer- und Messingwerke Akt.-Ges., Finow, near Eberswalde, Germany. No. 496,179 Dec. 28, 1926.

Foundry chaplet. Niederrheinische Eisenhütte und Maschinenfabrik Akt.-Ges., Dülken, Rhld., Germany. No. 495,982. Nov. 24, 1928.

Process and mold for making zinc cups for galvanic elements, batteries or the like, by die casting. A. Gassan Berlin-Frohnau and P. Ruck, Berlin, Germany. No. 495,983. July 19, 1928.

Electrical device for indicating the contents of ladles. Vereinigte Stahlwerke Akt.-Ges., Düsseldorf and E. Lange, Mülheim a. d. Ruhr, Germany. No. 495,985. Oct. 12, 1928.

Method of cooling the shaft and arms of mechanical roasting furnaces. F. Ryba, Sillein, Czechoslovakia. No. 496,185. Dec. 11, 1925; in Czechoslovakia Dec. 24, 1924.

Pyrometer. Siemens & Halske Akt.-Ges., Berlin-Siemensstadt, Germany. No. 495,906. Nov 4, 1927.

Process for hardening electrolytic deposits of chromium. P. Leistritz and F. Burghauser, Nürnberg, Germany. No. 496,004. May 31, 1927.

Method of reinforcing table ware at the places most subjected to wear, particularly their resting surfaces. Bremer Silberwarenfabrik Akt.-Ges., Sebaldsbrück, near Bremen, Germany. No. 495,832. Mar. 6, 1928.

Tank for electrolytic baths, particularly chromium-plating baths. Chrom-Industrie Max Wommer, Rüchmarsdorf, near Leipzig, Germany. No. 495,775. June 10, 1926.

Process for coating a body with platinum. N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands. No. 495,751. Oct. 20, 1926; in the Netherlands Oct. 14, 1926.

Furnace-charging and drying apparatus. R. Stelzer, Bautzen, Germany No. 495,915. Dec. 6, 1928.

Etching reagent for iron and ferrous alloys. Laboratorium für Metallkunde Dr. Leopold Rostosky, Berlin, Germany. No. 496,113. May 1, 1928.

Process and apparatus for pickling and washing thin sheet metal. J. Doubs, Berlin-Charlottenburg, Germany. No. 496,147. July 25, 1928.

Process for preventing the rusting of detinned sheet iron scrap, tin cans or the like. Th. Goldschmidt Akt.-Ges., Essen a.d. Ruhr, Germany. No. 496,189. (Addition to Patent No. 486,984.) May 30, 1928.

Upsetting or forging machine. Berlin-Erfurter Maschinenfabrik Henry Pels & Co., Akt.-Ges., Erfurt, Germany. No. 495,868. Nov. 6, 1928.

Mold for the aluminothermic welding of rails, the ends of which are pressed together. W. Brewitt, Berlin-Cöpenick, Germany. No. 495,777. Jan. 21, 1927.

Welding rod for cast iron. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 495,753. Aug. 24, 1928.

Welding composition. W. Reuss, Mannheim, Germany. No. 495,675. (Addition to Patent No. 468,540.) Nov. 2, 1928.

Welding metal for pure nickel. R. Werringloer, Gelsenkirchen, Germany No. 495,869. July 8, 1928.

Cold press for upsetting several enlargements in a single bar. J. Kuhne, Iserlohn i.W., Germany. No. 495,870. Oct. 8, 1925.

Production of flanges. Maschinenfabrik Hasenclever Akt.-Ges., Düsseldorf, Germany. No. 495,942. Apr. 24, 1928.

Process for making rods and tubing of soft or light metals with a coating of hard metal tubing. Deutsche Orthopädische Werke G.m.b.H., Berlin, Germany. No. 496,115. Dec. 13, 1925; in Great Britain Sept. 9, 1925.

Autogenous cutting burner using an illuminating gas hydrogen-oxygen mixture. S. Quirin, Ensheim, Saargebiet, Germany. No. 496,371. Oct. 20, 1928.

Device for uniformly feeding or winding and unwinding wire and strip which is worked once or several times between winding and unwinding. R. Blasberg, Merscheid, Ohligs, Rhld., Germany. No. 496,235. Dec. 28, 1927.

Metallurgical furnace for melting metals, particularly iron and iron alloys. E. Astima, Paris, France. No. 496,650. Dec. 22, 1927; in France Dec. 21, 1926.

Process for the direct production of pure iron from its ores by chlorination and decomposition of the volatile iron-chlorine compounds formed with the aid of hydrogen and application of heat. Vereinigte Stahlwerke Akt.-Ges., Düsseldorf, Germany. No. 496,634. Apr. 8, 1927.

Process for welding rails by the electric butt flash welding method. J. Otto Hennigsdorf, Osthavelland, Germany. No. 496,654. Feb. 3, 1928.

Alloy for magnetic purposes, particularly for loading telegraph and telephone conductors, composed of nickel, iron, copper and manganese, and having high magnetic permeability, especially for weak magnetizing forces. W. S. Smith, Newton Poppleford, Devonshire and H. J. Garnett, Sevenoaks, Kent, England. No. 496,334. Dec. 31, 1925; in Great Britain Nov. 20, 1925.

Electric induction furnace for melting or heat treating substances. Hirsch, Kupfer- und Messingwerke Akt.-Ges., Berlin, Germany. No. 496,462. Apr. 21, 1927.

Electrode seal for electric furnaces. Siemens & Halske Akt.-Ges., Berlin-Siemensstadt, Germany. No. 496,377. May 21, 1925.

Equipment for operating an electric melting furnace. Demag Akt.-Ges., Duisburg, Germany. No. 496,463. Oct. 27, 1928.

Device for making heating elements for electric furnaces. H. Kamps, Tervueren, Belgium and H. Zepernick, Brussels, Belgium. No. 496,256, Mar. 5, 1920.

Mechano-pneumatic stirring and rabbling device for electric furnaces. Société Electrométallurgique de Montricher, Paris, France. No. 496,335. Oct. 6, 1928; in France Feb. 7, 1928.

System of electric arc welding in a protective atmosphere. Allgemeine Elektricitäts Gesellschaft, Berlin, Germany. No. 496,464. Sept. 15, 1926.

Apparatus for arc welding in a protective atmosphere. Allgemeine Elektricitäts Gesellschaft, Berlin, Germany. No. 496,465. (Addition to Patent No. 496,464.) Nov. 10, 1926.

Process for melting metals in an electric arc surrounded by a protective atmosphere. Allgemeine Elektricitäts Gesellschaft, Berlin, Germany. No. 496,337. June 25, 1927; in the United States June 25, 1926.

Nickel or nickel alloy welding rod for electric arc welding. The International Nickel Co., Inc., New York, N. Y. No. 496,570. Oct. 17, 1926; in the United States Oct. 19, 1925.

Process for electric welding with polyphase current. M. Zack, Köln a.Rh., Germany. No. 496,313. Sept. 1, 1926.

Core-molding machine. L. Frankenschwert, Nürnberg, Germany. No. 496,661. June 22, 1928.

Process and molding machine for making all types of cores, using compressed air. F. Rolff, Sayn, Rhld., Germany. No. 496,383. Apr. 1, 1927.

Sand-slinging machine for making molds. Firma Franz K. Axmann, Köln-Ehrenfeld, Germany. No. 496,577. (Addition to Patent No. 439,347.) Apr. 18, 1928.

Molding machine. K. Werner, Dresden, Germany. No. 496,344. July 17, 1928.

Process for heat treating solid or semi-liquid ingots, using high-frequency currents. Eisen- und Stahlwerk Hoesche Akt.-Ges., Dortmund, Germany. No. 496,314. May 5, 1927.

Piston die-casting machine. J. Polak, Prague, Czechoslovakia. No. 496,265. (Addition to Patent No. 476,093.) Apr. 8, 1928.

Die-casting machine with spring-controlled mold parts. P. Rosenberger, Zuffenhausen, Württemberg, Germany. No. 496,315. (Addition to Patent No. 457,233.) Dec. 21, 1926.

Casting machine with revolving molds for making disk-shaped bodies of non-ferrous metals. Wheeling Stamping Co., Wheeling, W. Va. No. 496,470. July 5, 1927.

Device for purifying easily oxidizable metals. Allgemeine Elektricitäts Gesellschaft, Berlin, Germany. No. 496,347. Apr. 6, 1928; in the United States Apr. 6, 1927.

Silver alloy. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany No. 496,348. July 30, 1926. No. 496,349. June 20, 1926.

Process and apparatus for removing accumulations of hydrogen in electrolytic nickel plating baths. N. V. L. van der Hoorn's Chemische Technische Industrie, Utrecht, Netherlands. No. 496,531. Aug. 4, 1925; in the Netherlands Oct. 7, 1924.

Process for electroplating, using a bipolar electrode. Siemens & Halske Akt.-Ges., Berlin-Siemensstadt, Germany. No. 496,593. Mar. 22, 1928.

Accessories for baths for treating objects, particularly electrolytic baths. Siemens & Halske Akt.-Ges., Berlin-Siemensstat, Germany. No. 496,594. (Addition to Patent No. 486,531.) Jan. 29, 1929.

Forging machine. The National Machinery Co., Tiffin, Ohio. No. 496,596 Sept. 11, 1928.

Process for fusion welding and torch cutting, using compressed illuminating gas. F. Körner, Düsseldorf, Germany. No. 496,388. Nov. 15, 1927.

Welding metals. B. Racheef and M. Gofmann, Paris, France. No. 496,410. July 3, 1927; in France July 15, 1926.

Forging machine, especially for sharpening drills. Sullivan Machinery Co., Chicago, Ill. No. 496,411. Sept. 25, 1926; in the United States Sept. 29, 1925.

Construction of hydraulic presses for making tubing. A. Kreuser G.m.b.H. Hamm i.W., Germany. No. 496,829. June 30, 1928.

Continuous process for stamping out disk-like members from a strip of metal and lining the same up on a mandrel. V. R. Heftler, Detroit, Mich. No. 497,093. Dec. 18, 1928; in the United States Dec. 30, 1927.

Process for making plow-shares from tri-laminar sheet metal with a very hard surface and a tough soft core. Gussstahl-Werk Witten, Witten, Ruhr, Germany. No. 496,882. Sept. 13, 1927.

Process for roasting ores, particularly zinc blend. T. Lang, Frankfurt a.M., Germany. No. 496,715. Dec. 29, 1926.

Aluminum alloys. Metallgesellschaft Akt.-Ges., Frankfurt a.M., Germany. No. 496,856. Mar. 17, 1928.

Method of fatigue testing. Loesenhausenwerk Düsseldorfer Maschinenbau Akt.-Ges., Düsseldorf-Grafenberg, Germany. No. 497,079. June 27, 1925.

Electrolytic chromium plating process. Rawas Maatschappij, Swalmen, Netherlands. No. 496,892. Nov. 27, 1925.

Process for protecting metals against tarnishing. Deutsche Gold- und Silber-Scheideanstalt vormals Roessler, Frankfurt a.M., Germany. No. 496,972. Oct. 22, 1926.

Process and material for protecting iron and steel against rust. W. H. Cole, Paris, France. No. 496,933. Dec. 25, 1927; in Great Britain Jan. 1, 1927.

Rollable and drawable high-strength bimetal. Metallgesellschaft Akt.-Ges., Frankfurt a.M., Germany. No. 496,935. May 25, 1927.

Process for rolling zinc sheets. F. Jordan, Wickede, Ruhr, Germany. No. 497,300. June 13, 1928.

Arrangement of the backing rolls of rolling mills having four or six rolls. G. Reimer, Dahlbruch, Kr. Siegen, Germany. No. 497,393. May 4, 1927.

Device for sending rolled bars on to one or the other of two adjacent rollways after leaving the cooling bed. Demag Akt.-Ges., Duisburg, Germany. No. 497,620. Feb. 12, 1929.

Lead cable press. Siemens Brothers & Co., Ltd., London, and E. R. Hubbard, Brockley, Kent, England. No. 497,492. July 28, 1928.

Process for making brake shoes. C. Piehler, Berlin, Germany. No. 493,680. May 14, 1927.

Preparing iron and steel strip for cold rolling by coating with metal. Drahtwerk Hohenlimburg Boecker & Röhr G.m.b.H., Hohenlimburg i.W., Germany. No. 494,573. (Addition to Patent No. 448,102.) July 10, 1926.

Drive for roller beds, particularly those for rolling mills. P. Müller, Dortmund, Germany. No. 494,593. June 10, 1928.

Machine for making seamless metal tubing. E. C. Riebe, Paris, France. No. 494,203. Apr. 9, 1926.

Two-hand control for clutches, particularly those of presses, etc. H. Spörl, Stuttgart, Germany. No. 494,594. June 11, 1929.

Device for unwinding coils or wire and strip iron. Firma C. Matthaei, Offenbach a.M., Germany. No. 494,315. (Addition to Patent No. 445,491.) Feb. 23, 1929.

Production of calcium suitable for the absorption of nitrogen. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 494,212. Oct. 2, 1928.

Hollow brick for lining hot stoves or regenerators. K. Bremkamp, Berlebeck, near Detmold, Germany. No. 494,577. Dec. 6, 1927.

Device for heating rotary kilns in which ores, particularly iron ores, are reduced. Granular Iron Co., New York, N. Y. No. 494,435. July 26, 1927.

Process and device for improving the slag in a basically lined hearth furnace working with a high-phosphorus charge and a flux of phosphorite or phosphorite and sand. Witkowitzer Bergbau-und Eisenhütten-Gewerkschaft, Witkowitz, Mähren, Czechoslovakia. No. 494,511. Feb. 19, 1928.

Process and apparatus for annealing metal objects and the like in annealing boxes, the objects being protected from damage by the air during cooling by means of protective substances. Poetter G.m.b.H., Düsseldorf, Germany. No. 494,299 June 6, 1926.

Process for the continuous heat treatment of substances by means of a high-frequency field. C. Lorenz Akt.-Ges., Berlin-Tempelhof, Germany. No. 494,529. Apr. 1, 1928.

High-frequency induction furnace. Siemens-Schuckertwerke Akt.-Ges., Berlin-Siemensstadt, Germany. No. 494,530. Dec. 29, 1926.

Process for making electrodes. Ferro-Arc Welding Co., Ltd., London, England. No. 494,334. June 10, 1928; in Great Britain Aug. 26, 1927.

Process for making arc-welding electrodes provided with fluxing materials. E. Schröder, Berlin, Germany. No. 494,335. April 2, 1926.

One-piece chill molds for casting ingots and the like. T. Wymerskirch, Differdingen, Luxembourg. No. 494,338. July 20, 1928.

Device for casting aluminum and aluminum alloy ingots. Vereinigte Aluminium-Werke Akt.-Ges., Lautawerk, Lausitz, Germany. No. 494,339. Oct. 30, 1928.

Rotary tubular furnace with interchangeable and air-cooled conveying dogs. Metallgesellschaft Akt.-Ges., Frankfurt a.M., Germany. No. 494,151. Sept. 21, 1928.

Ore-carrier for Rund-Dwight-Lloyd machine. "Berzelius" Metallhütten-Gesellschaft m.b.H., Duisburg-Wanheim, Germany. No. 494,152. Mar. 28, 1929.

Recovery of zinc oxide from sulphidic ores or from metallurgical products and the like converted to sulphidic form by blast-roasting. E. J. Kohlmeyer, Berlin-Charlottenburg, Germany. No. 494,454. May 24, 1928.

Recovery of tin contained in tinning waste. Société Les Petits-Fils de François de Wendel & Cie., Paris, France. No. 494,455. Apr. 20, 1928; in France Jan. 23, 1928.

Horizontal, mechanically-driven high-pressure press. Heraeus-Vacuumschmelze Akt.-Ges., and W. Rohn, Hanau a.M., Germany. No. 497,493. June 22, 1926.

Process for making pipe bends of wrought iron. C. Hamacher Akt.-Ges., Gelsenkirchen, Germany. No. 497,494. (Addition to Patent No 473,095.) Sept. 27, 1928.

Device for use on all kinds of presses for preventing entry of several pieces at the same time or too thick pieces. L. Schuler Akt.-Ges., Göppingen, Württemberg, Germany. No. 497, 469. July 21, 1927.

Tubing mill. Electromotoren-Werke Hermann Gradenwitz, Berlin, Germany, No. 497,609. June 2, 1927.

Process and apparatus for producing iron from ore. S. C. G. Ekelund, Stockholm, Sweden. No. 497,572. Oct. 19, 1926; in Sweden, Oct. 19, 1925.

Puddling installation with a puddling furnace rotating about a horizontal axis, and having helical projects on the inside. F. Begus, Gorizia, Italy. No. 497,632. May 30, 1928.

Process for producing iron from scrap, as well as for the direct production of iron from ore in the reverberatory furnace. F. W. Corsalli, Berlin, Germany. No. 497,302. Dec. 14, 1924.

Electric furnace. Wild-Barfield Electric Furnaces, Ltd., and L. W. Wild, London, England. No. 497,350. June 20, 1928; in Great Britain Apr. 10, 1928.

Process for producing a current-conducting metallic jacket on unbaked carbon electrodes. Firma C. Conradty, Nürnberg, Germany. No. 497,351. May 8, 1927.

System for the continuous operation of several electric furnaces one behind the other, for the purpose of obtaining iron and steel by using the same electric equipment. Akt.-Ges. Brown, Boveri & Cie., Baden, Switzerland. No. 497,352. May 16, 1924.

Electromagnetically controlled hydraulic regulator for electro-metallurgical furnaces. L. Tagliaferri, Genoa, Italy. No. 497,353. Dec. 13, 1927.

Device for charging materials into a cupola or into the forehearth of a cupola. Hannoversche Eisengiesserei und Maschinenfabrik Akt.-Ges., Hannover, Germany. No. 497,260. May 4, 1929.

Lifting and turning device for molding machines making simultaneously the two halves of a flaskless mold. Feuer und Luft, Gesellschaft für Feuerungs- und Lüftungsanlagen m.b.H., Köln-Ehrenfeld, Germany. No. 497,398. May 3, 1927.

Process for making zinc cups for galvanic elements, batteries or the like, by die-casting. A. Gassan, Berlin-Frohnau. Germany. No. 497,648. (Addition to Patent No. 495,983.) Oct. 30, 1928.

Removal of copper from impure metals and alloys. H. Harris, London, England. No. 497,312. Feb. 21, 1928; in Great Britain Feb. 21, 1927.

Production of difficulty workable or unworkable bodies of high density. Patent-Treuhand-Gesellschaft für elektrische Glühlampen m.b.H., Berlin, Germany. No. 497,558. June 30, 1927.

Hardness tester with hammer guided in a tube. Établissments Vallaroche, Paris, France. No. 497,582. June 5, 1927; in France Nov. 2, 1926 and May 3, 1927.

Method of making abrasion or wear tests on materials rubbing against each other. M. Fink, Berlin-Lichterfeld, Germany. No. 497,521. July 7, 1928.

Process for cleaning noble metals with the aid of alkaline solutions. Carl Mann & Co., G.m.b.H., München, Germany. No. 497,440. Aug. 2, 1927.

Etching machine. A. Holmström, Monte Carlo, Monaco. No. 497,280. Nov. 15, 1927.

Plate holder for etching machines. A. Holmström, Monte Carlo, Monaco. No. 497,281. Nov. 15, 1927.

Automatic torch cutting machine. W. Eberle, Frankfurt a.M., Germany. No. 497,400. (Addition to Patent No. 477,933.) Apr. 19, 1929.

Italian Patents

Subject of Invention, Patentee, Patent No., and Filing Date

Method of making high-speed steel having a high content of vanadium and cobalt. Stahlwerk Becker A. G., Willich, Krefeld, Rhld., Germany. No. 265,662. Dec. 14, 1927; in Germany Dec. 30, 1926.

Inprovements in the manufacture of lead-antimony alloys for cable sheaths and the like. Standard Elettrica Italiana, Milano, Italy. No. 265,294. Dec. 23, 1927.

Process for bright-annealing metallic objects in an air-free gaseous atmosphere without the use of pots. Akt.-Ges., Brown, Boveri & Cie., Baden, Switzerland. No. 265,370. Dec. 14, 1927; in Germany Dec. 27, 1926.

Semi-automatic machine for casting under pressure. E. Brumm, Lyon, France. No. 265,384. Dec. 14, 1927; in France Dec. 15, 1926 (Importation of French Patent No. 629,808).

Improvements in electric resistance welding. G. Malaguti, Milano, Italy. No. 265,359. Dec. 6, 1927.

Double electrode for continuous electric welding. G. Malaguti, Milano, Italy. No. 265,411, Dec. 6, 1927.

Mold for the aluminothermic welding of rails. H. Schultz, Berlin-Lankwitz, Germany. No. 265.511. Dec. 23, 1927; in Germany Apr. 6, 1927.

Method of preventing surface carburization and decarburization in annealing iron and steel containing carbon. Vereinigte Stahlwerke Akt.-Ges., Düsseldorf, Germany. No. 265,378. Dec. 23, 1927; in Germany Jan. 8, 1927, in the name of E. H. Schulz and W. Hülsebruck.

Apparatus for electroplating objects in bulk, particularly for chromium-plating. V. Zanotti, Milano, Italy. No. 265,372. Dec. 15, 1927.

Method of prolonging the life of electric-furnace electrodes. A. Leopold, Paris, France. No. 265,597; in Austria Dec. 6, 1926.

Process and apparatus for use with shaft furnaces for the treatment of granular materials. Metallbank und Metallurgische Gesellschaft Akt.-Ges., Frankfurt a.M., Germany. No. 265,399. Dec. 17, 1927; in Germany Feb. 3, 1927.

Process for making self-baking electrodes. Gebrüder Siemens & Co., Berlin-Lichtenberg, Germany. No. 265,558. Dec. 28, 1927; in Germany Jan. 21, 1927.

Norwegian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for reducing zinciferous materials. The New Jersey Zinc Co., New York, N. Y. No. 47,693. Aug. 27, 1927

Process for desulphurizing sulphidic ores. T. W. Tharaldsen, Oslo, Norway. No. 47,694. Mar. 22, 1928.

Corrosion-resistant aluminum alloys and process for making the same. P. Berthélemy, and H. de Montby, Paris, France. No. 47,696. Jan. 14, 1928.

Furnaces for producing aluminum. P. E. Froland, Hoyanger, Norway. No. 47,697. Mar. 10, 1928.

Malleable nickel, molybdenum-chromium alloy. T. D. Kelly, London, England. No. 47,753. Sept. 3, 1927.

Process for hardening the outer layers of cast iron. Aubert et Duval Frères, Paris, France. No. 47,774. Mar. 1, 1928.

Process for producing high-strength structural iron members. Vereinigte Stahlwerke Akt.-Ges., Düsseldorf, Germany. No. 47,775. Oct. 30, 1929.

Bright-annealing furnace, with cooling device. Siemens-Schuckertwerk Akt.-Ges., Berlin-Siemensstadt, Germany. No. 47,844. May 9, 1928.

Electric bright annealing furnace. Siemens-Schuckertwerke Akt.-Ges., Berlin-Siemensstadt, Germany. No. 47,845. May 31, 1929.

Process and apparatus for the reduction of zinciferous materials. The New Jersey Zinc Co., New York, N. Y. No. 47,855. Aug. 10, 1927.

Process for producing pure iron. H. J. van Royen, Hörde, Westfalen, Germany. No. 47,874. Dec. 6, 1927.

Automatic control devices for electric arc welding apparatus and the like. W. R Hume, Melbourne, Victoria, Australia. No. 47,880. Jan. 28, 1926.

Electrodes for electric furnaces. Société Electrométallurgique de Montricher, Paris, France. No. 47,881. Dec. 20, 1927.

Inductive heating of elongated bodies. Finspong Metallwerks A.B., Finspong, Sweden. No. 47,882. Feb. 28, 1928.

Process for roasting sulphide ores. J. B. Read and M. F. Coolbaugh, Golden, Colo. No. 47,888. Oct. 6, 1928.

Aluminum alloy which is resistant to corrosion and to sea water. Vereinigte Aluminium-Werke, Lautawerk, Lausitz, Germany. No. 47,889. Sept. 12, 1927.

Process for making aluminum alloys. A. Geyer, Paris, France. No. 47,890. Feb. 3, 1928.

Process for removing halogen ions, particularly from electroplating baths. Metallgesellschaft Akt.-Ges., Frankfort a.M., Germany. No. 47,891. Nov. 30. 1928.

Process for dry reduction of iron ore or products thereof. Norsk Hydro-Elektrisk Kvaelstof Aktieselskab, Oslo, Norway. No. 47,907. Jan. 23, 1926.

High-frequency induction furnace. Siemens & Halske Akt.-Ges., Berlin-Siemensstadt, Germany. No. 47,536. Sept. 30, 1927.

Process for the production of aluminum by fusion electrolysis. I. G., Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 47,541. Dec. 24, 1927.

Lining for electric induction furnaces and process for making the same. Finspongs Metallwerks Aktiebolaget, Finspong, Sweden. No. 47,563. Sept. 4, 1926.

Process for roasting and/or sintering ore fines or other finely subdivided materials. Cie. des Metaux Overpelt Lommel (Sté. Ame.), Overpelt-lez-Neerpelt, Belgium. No. 47,567. Jan. 20, 1928.

Alloy composition. T. D. Kelly, London, England. No. 47,568. Sept. 7, 1927.

Process and machine for the electric forging and shaping of iron and steel bars. Société Holding des Brevets et Procédés Giacchino pour l'Embauchage Electrique, Geneva, Switzerland. No. 47,598. Nov. 7, 1928.

Process for the production of non-corrodible aluminum alloy objects. Aluminum Ltd., Toronto, Ont. No. 47,602. Apr. 19, 1927.

Process for the production of metallic magnesium. M. N. Lacelle, London, England. No. 47,604. Feb. 28, 1927.

Press for stamping and pressing sheet metal and the like. F. Humphries, Parkstone, Dorset, England. No. 47,617. Nov. 26, 1927.

Swedish Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Transformer for electric welding. Ateliers de Construction Electrique de Charleroi, S. A., Charleroi, Belgium. No. 69,387. Dec. 31, 1927. Priority Dates: Jan. 4, and Oct. 12, 1927.

Method of Casting steel and other metals in chill molds. A. G. Hultgrén, Söderfors, Sweden. No. 69,391. Aug. 8, 1927.

Process for producing alloyed tungsten. E. A. A. Grönwall, Stockholm, Sweden. No. 69,397. May 15, 1928.

Housing for rolling mills having roller or ball bearings. A. B. Svenska Kullagerfabriken, Göteborg, Sweden. No. 69,531. Mar. 23, 1923.

Method of making bushings. The Cleveland Graphite Bronze Co., Cleveland, Ohio. No. 69,532. Aug. 3, 1929.

Electrolytic process for the production of magnesium and alkaline earth metals. A. C. Jessup, Paris, France. No. 69,543. July 27, 1926. Priority Dates: July 29 and Aug. 5, 1925, and Apr. 22, 1926.

Electrolytic process for the production of magnesium and alkaline earth metals, and apparatus therefor. A. C. Jessup, Paris, France. No. 69,544. Sept. 30, 1926. Priority Dates: Oct. 9, 1925, and Mar. 30, 1926.

Process for hardening high-speed steel. W. Stauffer, Zürich, Switzerland. No. 69,570. Mar. 26, 1928. Priority Date: Apr. 23, 1927

Swiss Patents

Subject of Invention, Patentee, Patent No., and Filing Date

Electric soldering iron. I. Knowles and F. Knowles, Buckingham, England. No. 136,098. July 6, 1928; in Great Britain July 6, 1927 and June 28, 1928.

Electrode for arc welding and process for making the same. F. Dworzak, Wien, Austria. No. 136,099. July 30, 1928; in Austria Oct. 12, 1927.

Process for sintering, burning or roasting materials, and furnace for working this process. E. C. Loesche, Berlin-Lankwitz, Germany. No. 136,310. Oct. 10, 1928; in Germany Oct. 14, 1927.

Process for producing an adherent coating on iron, aluminum, tin, lead, magnesium, zinc, cadmium and their alloys. A. Pacz, East Cleveland, Ohio. No. 136,399. June 18, 1927.

Steel-hardening process. O. Kröning, Hanover-Linden, and R. Boes, Harber, Hanover, Germany. No. 136,442. June 1, 1927.

Method and means for shifting the holdon the electrodes of electric furnaces. Dr. Alex. Wacker Ges. für electrochemische Industrie G.m.b.H., München, Germany. No. 136,502. Oct. 26, 1928.

Holder for electric furnace electrodes. Siemens-Plania Akt.-Ges. für Kohlefabrikate, Berlin-Lichtenberg, Germany. No. 136,503. Dec. 26, 1928; in Germany May 4, 1928.

High-lead bearing alloy. Firma: Jacob Newrath, Vienna, Austria. No. 136,575. (Addition to Patent No. 118,497.) Jan. 9, 1928; in Poland Jan. 17, 1927.

Process for the production of a resistant coating on objects of aluminum and aluminum alloys. C. H. R. Gower, and Stafford O'Brien & Partners Ltd., both of London, England. No. 136,660. Feb. 4, 1928; in Great Britain Oct. 20, 1927.

Process for the production of metallic coatings on objects made of aluminum or aluminum alloys. C. H. R. Gower and Stafford O'Brien & Partners Ltd., both of London, England. No. 136,661. Feb. 4, 1928; in Great Britain Oct. 25, 1927.

Process for pickling metals. Gesellschaft für chemische Industrie in Basel, Basel, Switzerland. No. 136,662. June 7, 1928.

Process for casting ingots in vertical rotating molds. Mannesmannröhren-Werke, Düsseldorf, Germany. No. 136,703. Sept. 25, 1928; in Germany June 15 and Aug. 1, 1928.

Steel die. Aubert & Duval Frères, Paris, France. No. 136,704. Jan. 23, 1929; in Germany Feb. 6, 1928.

Multiple wire-drawing machine. Les Frères Breguet, Geneva, Switzerland. No. 136,705. Dec. 15, 1928.

Process for shaping hollow objects. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. No. 136,706. Jan. 22, 1929; in the United States Jan. 24, 1928.

Process for increasing the yield point and elastic limit of alloyed aluminum wire. Aluminium Industrie Akt.-Ges., Neuhausen, Switzerland. No 136,707. Feb. 8, 1929; in Germany Feb. 28, 1928.

Induction furnace. Siemens & Halske Akt.-Ges., Berlin-Siemensstadt, Germany. No. 136,847. (Addition to Patent No. 131,920.) Nov. 2, 1928; in Germany Dec. 8, 1927.

Process for producing coatings on aluminum and its alloys. B. Jirotka, Berlin, Germany. No. 136,935. Mar. 6, 1928; in Germany Mar. 10, 1927.

Process for sintering ore fines in a furnace which automatically discharges the sintered product. V. Wellens, Lausanne, Switzerland. No. 136,975. Dec. 10, 1928.

Process and cuopla for the production of malleable cast iron. O. Brauer, Mettmann, Germany. No. 136,976. June 12, 1928; in Germany May 21, 1928.

Austenitic chrome-nickel steel. Fried. Krupp Akt.-Ges., Essen-Ruhr, Germany. No. 136,977. Jan. 17, 1929; in Germany Feb. 9, 1928.

Process for filtering metals. British Maximum Ltd., Manchester, England. No. 136,978. Nov. 5, 1928; in France Nov 7, 1927.